



UNITED STATES  
DEPARTMENT OF THE INTERIOR  
BUREAU OF MINES  
WASHINGTON 25, D. C.

October 15, 1952

Mr. James K. Remsen  
Director of Materials  
National Security Resources Board  
Executive Office of the President  
Room 220  
Washington 25, D. C.

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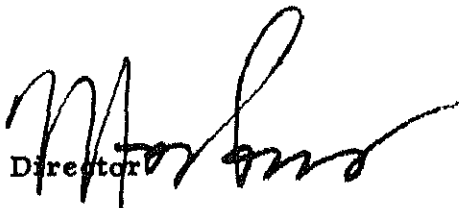
Dear Mr. Remsen:

Forwarded herewith are copies of the "Materials Survey -  
Langanese", prepared by the Bureau of Mines for the National Security  
Resources Board, with the cooperation of the Geological Survey.

This report, one of the series of basic surveys on various  
strategic and critical materials being prepared at the request of the  
National Security Resources Board by selected Government agencies,  
conforms in contents and format with the working fund agreement of  
May 31, 1950, between the Board and the Bureau of Mines, with the  
general outline proposed by the Board, and with decisions reached at  
various interagency conferences.

Manuscript revisions proposed by reviewing officials of  
both the National Security Resources Board and the Munitions Board  
have been incorporated in the Survey,

Sincerely yours,

  
Director

closure

## PREFACE

The Materials Survey series is being prepared under the sponsorship of the National Security Resources Board with the cooperation of a number of departments and agencies. This volume, covering the commodity Manganese, is one of the several in the series prepared by the Bureau of Mines, Department of the Interior.

A definition and description of manganese and its ores is contained in the first chapter. Chapter II deals with world-wide reserves in general while chapter III covers the specifications of manganese ores and various uses. Chapters IV, V, and VI describe the mechanics of stockpiling, ore treatment and metallurgical refining processes. United States manganese deposits are discussed in chapter VII while chapters VIII through XIII deal with natural deposits by geographical areas. Chapter XIV discusses secondary manganese sources and chapter XV, ore recovery. World trade and United States tariffs are covered in chapters XVI and XVII. Chapter XVIII describes the various uses of manganese while Chapters XIX, XX and XXI provide a description of the industry, consumers, producers, and processors. A historical survey of manganese through World Wars I and II is presented in chapter XXII and finally chapter XXIII presents a series of business statistics.

The report is presented in looseleaf form to facilitate further individual inclusions. Tables and charts are prepared for the inclusion of more recent data where possible.

The survey was prepared by a special staff assembled in the United States Metals and Alloys Branch, Minerals Division, Bureau of Mines, and under the supervision of Norwood B. Melcher, Chief, United States Metals and Alloys Branch and Robert H. Ridgway, formerly Chief of that branch. The report was written by Roland D. Parks of the Massachusetts Institute of Technology and Edgar J. Gealy, Commodity Industry Analyst of the Bureau of Mines with the exception of data on world trade which was assembled by the Department of Commerce.

The manuscript has been reviewed in whole or in part by specialists of the Bureau of Mines, the Geological Survey, the National Security Resources Board, and the Munitions Board. Substantial contributions were made by individuals of the above organizations as well as other government agencies and many persons in industry for which the authors are deeply grateful.

## FOREWORD

The purpose of this report is fourfold; (1) To outline the world manganese situation as to sources of supply, trade, and consumption; (2) to describe the technical processes essential to production and use of manganese, to cite significant present research, and to note evident problems that will require attention soon; (3) to describe briefly all known deposits of manganese minerals that appear promising enough to provide possible future sources of supply; and (4) to provide a fairly complete list of references so that economic, technical, and geological details may be readily investigated.

The original plan and commission for this handbook carried with it the high aim for a definitive and complete survey - an aim that grew from the need for assembling in one place a great deal of material information from a great many sources. To assess this information authoritatively would call for the combined efforts of such a wide range of specialists as to be out of range of the present study. The original purpose and goal have constantly motivated the authors and their associates in the collecting of material, and it is their sincere hope that a creditable and usable approximation of the original commission has been reached.

As the work progressed, it became apparent that the static nature of the aim and the fluid nature of the subject were at odds. Manganese, like other minerals and indeed all natural resources, may be treated as fixed only in its natural state before development. Once mined, processed, and a subject for trade, it enters a picture of constant change until the resource is exhausted. For this reason we worked on this material cannot assert its comprehensiveness or finality.

We wish to acknowledge with sincere gratitude the generous assistance of many people in the Government agencies, especially in the United States Departments of Interior and Commerce on whom we called frequently.

## INTRODUCTION

Manganese is essential for making steel. In present steel-making practice, manganese serves as a deoxidizer and desulfurizer, a dual function for which no comparable substitute has been found. Some 13 or more pounds of manganese per short ton of finished steel are added to the molten bath in the final stages of the open-hearth process. This manganese is usually in the form of ferromanganese, a special alloy containing about 80 percent manganese, and is used in addition to the manganese contained in the ores and other materials consumed in the making of steel.

With domestic steel capacity exceeding <sup>100</sup> 1,000,000,000 tons per year and pointed higher, the vital nature of manganese is readily apparent. For this single purpose - that of making steel - current capacity calls for over 650,000 tons of contained manganese per year, which, when converted to the average metallurgical-grade ore, will bring annual ore requirements to about 1,500,000 tons.

Other important uses of manganese, definitely secondary in tonnage to the steel-making demand, include the production of many special-purpose alloy steels wherein manganese has the property of alloying with iron in all proportions, and the common dry-cell battery in which high-grade manganese dioxide acts as the depolarizing agent.

The strategic nature of manganese is intensified by the geographic location of the major manganese deposits with relation to steel-making centers. With the exception of the U.S.S.R., large deposits of metallurgical-grade manganese ores are not found close to the centers of heavy industry. The bulk of the world's steel is produced in north-eastern United States, from Chicago to Pittsburgh, in western Europe, and in Russia, from the Donets Basin to the Kuznets. Excluding Nikopol and Chiaturi in southern Russia, the world's manganese ores come mainly from India, the Gold Coast, the Union of South Africa, Brazil, and other distant localities, all long sea routes to points of major consumption. Manganese certainly involves the largest tonnage of any strategic mineral and probably the longest average haul. This is especially true for the United States, largest world consumer of manganese.







## I. DEFINITION & DESCRIPTION



## CHAPTER I. DEFINITION AND DESCRIPTION

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## I. DEFINITION AND DESCRIPTION

### A. SOURCES OF MANGANESE ORE

Manganese ores and minerals are widespread throughout the world. Of more than 60 countries of record, some 30 may be considered as reasonably consistent producers of commercial ores running 35 percent or higher in manganese content. Most of these ores are for metallurgical use and some for battery, chemical, and other nonmetallurgical purposes.

Producers, as far as the past record is concerned, may be divided readily into four groups, as follows:

1. U.S.S.R. producer of nearly one-half the world's manganese; annual output, 1,000,000 to 3,000,000 metric tons of ore.
2. Six other major producers in the range from 100,000 to 1,000,000 tons per year. In descending order, based on the past five years production average, these are: Gold Coast, India, Union of South Africa, Brazil, United States, French Morocco.

Over the long period, India has ranked second only to U.S.S.R. in output and is the only source in group 2 with output at times exceeding 1,000,000 tons. Cuba was a major producer during 1937-46, but is not expected to regain this position owing to depletion of reserves. French Morocco, until recently a smaller producer, apparently has capacity and reserves adequate to maintain or improve its current position as a major source, given future outlets for the product.

During World War II, Japan was in the major group and might regain such a position, although reserves are thought to be inadequate for continued high output.

3. Fifteen intermediate sources in the range of 10,000 to 100,000 tons output per year. In approximate descending order, these are: Egypt (ferruginous manganese ore), Cuba, Japan, Mexico, Republic of the Philippines, Germany (French Zone), Indonesia, Rumania, Hungary, Chile, Spain, Italy, China, Sweden, Belgian Congo, United Kingdom.





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Of this group, Egypt, Mexico, the Philippines, Chile, and Belgian Congo may be expected to move upward on the production list, with Egypt, in all probability moving to group 2, where it would have been placed in the period just before World War II. The Sinai Mines were out of production from 1941 to 1949 because of war damage. Egypt's production, however, is ferruginous manganese ore, and for this reason Egypt will not be referred to generally throughout this report as a producer of manganese ore.

4. Eight minor producers of reasonable continuity with outputs below 10,000 tons per year, as follows:  
Portugal, Australia, Turkey, Northern Rhodesia  
Argentina, Indochina, Malaya, Portuguese West  
Africa (Angola).

Of these, Turkey and Angola could well move to group 3 in the near future based on present trend.

It is interesting to note that the U.S.S.R., Rumania, Hungary, and China, in recent years, supplied almost exactly one-half of the world production, with the remaining 26 countries producing the other half. Since 1948, however, the portion attributable to the U.S.S.R. group has been declining steadily.

In considering the distribution of manganese, the relation of political and industrial geography to mineral geography is worth noting. Distribution of minerals is not related to political geography, whereas industrial geography is.

The steel centers of the world are located in relation to iron, coal, transportation, and markets. In general, they occur across the north temperate zone from Chicago to Siberia. At present some outlying steel centers are coming into their own in South Africa, India and elsewhere. No major producer of steel except the U.S.S.R. has manganese ore tributary to its steel centers. To supply the major steel centers of the United States and western Europe, manganese ores must be transported long distances from such sources as India, South Africa Gold Coast, Brazil, Russia, etc.

It may be said then that manganese, which is vital to steel, is not usually found at or near the places where it is used.

## 1. Manganese Resources

### Digest of World Situation

Salient features of the world manganese ore situation are:

1. The U.S.S.R. has, roughly, one-half of the current world's productive capacity and known reserves.
2. The manganese resources of the United States, though important in terms of potential contained metal, are almost entirely of such low-grade material as to be noncommercial at present price levels.
3. The principal undeveloped standard-grade resources known in the Western Hemisphere are in Brazil, at Amapa and Urucum, either of which could provide substantial output for many years.
4. India and the Union of South Africa are known to have major reserves of manganese ores of the general order of magnitude of 100 000,000 tons, second only to the U.S.S.R. These two countries, together with the Gold Coast, French Morocco, and Brazil, appear to be our most logical sources for immediate delivery of large tonnages of standard-grade ores.
5. Some 10 or more other foreign countries outside the present sphere of the U.S.S.R. offer in the aggregate an additional important source of standard-grade ores for immediate delivery.

### Digest of United States Situation

Salient features of the United States situation in regard to manganese resources are:

1. Records of the Federal Geological Survey and the Federal Bureau of Mines show that over 99 percent of known United States manganese-metal resources are to be found in 12 deposits; the balance is distributed among more than 1,000 small showings.
2. The bulk (about 93 percent) of the potential United States manganese resources, as known today, are in four localities - the Cuyuna range, Minn.; the Chamberlain area, S. Dak.; the Artillery Mountains, Ariz.; and Arcostook County, Maine.

3. Butte and Philipsburg, Mont., and, to a smaller extent, Batesville Ark., are the only significant commercial sources of standard-grade manganese ore and concentrates at present.

4. Reclamation of manganese now wasted in the United States in basic open-hearth furnace slags would reduce requirements for new ore in important amounts.

5. Metallurgical problems now complicate efficient extraction of the manganese from each of the four large deposits. In addition, underground mining will be necessary for the bulk of the tonnage at Artillery Peak, Ariz., and in Aroostook County, Maine. This will add to the cost and may limit the rate of output.

#### B. ESTIMATED NEAR FUTURE POTENTIAL OF MAJOR WORLD SOURCES

The current upsurge in production of manganese ores in India and the Union of South Africa, coupled with current developments in Brazil and the Belgian Congo, particularly, indicate a formidable shift in the pattern of world supply within the next few years. Given continuance of favorable trade relations with the United States as the world's major consumer and continuance of favorable relations with major United States sources of capital for foreign development and assuming no let-up in demand for some years to come, it seems plausible to estimate the potential capacities of the major world sources, excluding U.S.S.R., say 3 to 5 years hence, in round figures about as follows:

	Total Potential	Available to the United States
India	1,000,000 +	600,000 +
Brazil	900,000 +	800,000 +
Gold Coast	800,000 +	400,000
Union of South Africa	600,000	500,000
French Morocco	300,000 +	100,000
Belgian Congo	100,000 +	100,000
Cuba		75,000



## C. DEFINITION OF "ORE"

In connection with mining and mineral raw material, the word "ore" is often used loosely. By usual standards, a mineral-bearing material is not ore unless it can be worked at a profit. This, of course, is not true under all types of political economy. Strictly speaking, then, we may define ore as "an aggregation of minerals from which one or more mineral products may be extracted profitably." This qualification of profit applies to any given set of cost-price relationships that are subject to change by any one of a number of factors. For instance, a rise in the price of metal may make ore tomorrow out of what was not ore yesterday, and a similar change may result from a reduction of capital overhead charges. What is ore to one operator may not be ore to another, depending upon the relative efficiency of the operations.

Throughout this report, an endeavor will be made to use the word ore in its strict sense. In speaking of untried mineral deposits - those under exploration - the term "mineral" or "mineral-bearing material" will be used rather than the term "ore", since the cost-price relationship is not known. This is not intended to imply that use of the word "ore" will not be considered correct if and when these deposits are exploited.

### 1. Mineralogy

Manganese, the sixteenth most common element in the earth's crust, is widely distributed the world over, but never in the metallic state. Because of its high affinity for oxygen, it most often occurs as part of an oxide mineral and frequently in either a silicate or a carbonate. Of the more than 125 minerals of manganese, only a few have economic importance. These minerals, as well as their approximate compositions and manganese content, are shown in the following table.

Table I-1. IMPORTANT MANGANESE MINERALS

Name	Composition	Mn, percent
Pyrolusite	MnO	63
Psilomelane	MnO.MnO <sub>2</sub> .2H <sub>2</sub> O	45-60
Wad	Hydrous Mn oxide	variable
Manganite	Mn <sub>2</sub> O <sub>3</sub> .H <sub>2</sub> O	62.4
Hausmannite	Mn <sub>3</sub> O <sub>4</sub>	72.5
Braunite	Mn <sub>2</sub> Si <sub>2</sub> O <sub>3</sub>	69
Rhodochrosite	MnCO <sub>3</sub>	47.5
Rhodonite	MnSiO <sub>3</sub>	42
Bementite	2MnSiO <sub>3</sub> .H <sub>2</sub> O	39

Pyrolusite: MnO<sub>2</sub>, generally with some H<sub>2</sub>O; 63.19 percent manganese, 36.81 percent O when pure. Color varies from grayish black to black, with a metallic luster. The ordinary variety is massive, fibrous, columnar, or nodular. Its hardness (H.) is 2 to 2.5. Hardness, mineralogically, is a relative term, with talc, the softest mineral known, having an assigned hardness of 1 on the Mohs scale and diamond, the hardest mineral, with an assigned hardness of 10. Pyrolusite is soft enough to soil the fingers. Its specific gravity (G.) varies from 4.4 to 5.0. Occasionally pyrolusite is found in the crystalline state, when it may be known as polianite. In this state it is hard, dense, and anhydrous; H., 6 to 6.5, G., 5.06  $\pm$  .02. Fleischer and Richmond, well-known for their mineralogical investigations of manganese minerals, believe that the name polianite should be dropped.

Pyrolusite is one of the most common, if not the most common, manganese minerals. Apparently it always forms under highly oxidizing conditions. It is found in bogs, shallow marine deposits, in the oxidized zone of manganiferous-ore deposits, and in deposits formed by circulating waters. It is undoubtedly transported as a colloid, and bacteria are important in its precipitation. It is associated with other manganese minerals and, with similar iron compounds, often contains minor amounts of silica, lime, and barite. Manganite alters readily to pyrolusite, and some deposits of the latter are largely secondary after manganite. Important occurrences are found in the Russian Caucasus, in India, in the Gold Coast, in Brazil, in Cuba and Central America, and in the United States at Batesville, Ark., and Philipsburg, Mont.

Psilomelane: Composition uncertain; often given as  $\text{MnO} \cdot \text{MnO} \cdot 2\text{H}_2\text{O}$ , but recent studies indicate  $\text{Ba}(\text{Mn}, \text{Fe})_8\text{O}_{16} \cdot 2\text{H}_2\text{O}$  as type formula. Analyses run 6-10 percent MnO plus 67-73 percent  $\text{MnO}_2$ . The color is iron-black to dark steel-gray, with a dull, sub-metallic luster. It is amorphous and usually massive, crusty, stalactitic, botryoidal or earthy. The hardness is 5-6, decreasing in earthy varieties; G.,  $4.71 \pm .01$ . Psilomelane is a secondary mineral which forms under conditions of temperature and pressure that are normal to the earth's surface. It is commonly a weathering product of manganese silicates and carbonates. It is frequently associated with pyrolusite, goethite and limonite (iron oxides), with hausmannite and braunite, and with small quantities of barite and potash. Like pyrolusite it is probably transported colloiddally. It is an alteration product of many minerals, such as manganite, rhodochrosite, franklinite ( $\text{Fe}, \text{Mn}, \text{Zn})\text{O} \cdot (\text{Fe}, \text{Mn})_2\text{O}_3$ ), and hubnerite ( $\text{Mn} \cdot \text{WO}_4$ ). It is also occasionally pseudomorphous after calcite, fluorite, barite, and other minerals. It is the most abundant ore mineral in the Indian deposits. Also found at Miguel Burnier in Brazil and at Negaunee, Mich., associated with hematite, and in significant amount at Nikopol (Russia).

Cryptomelane is the name proposed recently for the potassium variety of psilomelane, whose composition is probably  $\text{K}(\text{Mn}, \text{Fe})_8\text{O}_{16}$ . Heretofore, this variety, one of the commonest manganese oxide minerals, has been confused with psilomelane although it has been referred to by mineralogists as "true psilomelane."

Wad: Chiefly, hydrous manganese oxide. Analyses range from 26-75 percent MnO without any  $\text{MnO}_2$  to 3-12 percent MnO with 35-62 percent  $\text{MnO}_2$ . It is predominantly an oxide of manganese with 3-25 percent  $\text{H}_2\text{O}$ , and up to 10 percent or more BaO. Wad is not actually a mineral but a mixture of compounds such as pyrolusite and psilomelane and various other hydrous oxides, such as those of Cu, Co, Fe, Pb, Li, W, Al, etc. Varieties include common "bog manganese"; cobaltian, called "asbolite"; cuprian, called "lampadite"; ferrian, plumbian etc. Wad is earthy and usually occurs in compact, structureless masses that may or may not be pisolitic. 1 / Usually very soft, but may reach H., 6; G., 2.8 to 4.4. It is black or brown.

Manganite:  $\text{MnO}(\text{OH})$  or  $\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$ , a basic oxide of manganese. Theoretical composition, 49 percent  $\text{MnO}_2$  and 40 percent MnO, based on active oxygen content. Color varies from steel-gray to iron-black,

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1 / Pisolitic, from "pisoform", meaning like a pea in size and shape.

with a submetallic luster. H., 4; G., 4.2 to 4.4. Usually found as crystals, though sometimes columnar or stalactitic. It is commonly associated with pyrolusite, psilomelane, hausmannite, limonite, or goethite. Prominent gangue minerals are calcite and barite. Manganite is found as a low-temperature vein mineral, in acid igneous rocks, especially, and as replacements and deposits formed by meteoric waters. It is frequently altered to pyrolusite, hence the association; other alteration products are psilomelane, braunite, and hausmannite. It occurs in Sandur district, India, and in California.

Hausmannite:  $\text{Mn Mn}_2\text{O}_4$  or  $\text{Mn}_3\text{O}_4$ . Theoretically, 38 percent  $\text{MnO}_2$  and 62 percent MnO. When pure, 72.5 percent manganese. Color brownish black with a dull metallic luster. H., 5 to 5.5; G., 4.72 to 4.86. The mineral is primary, occurring in high-temperature hydrothermal veins in association with acid igneous rocks. It is found as a contact metamorphic mineral and also as a recrystallization product in metamorphosed sedimentary or residual manganese-ore deposits. It may be produced artificially by sintering carbonates and oxides. Hausmannite is quite rare, although widely distributed. It occurs in the Brazilian manganese deposits, and in the United States it is an important constituent of the ores at Batesville, Ark.

Braunite:  $(\text{Mn.Si})_2\text{O}_3$  or  $3\text{Mn}_2\text{O}_3 \cdot \text{MnSiO}_3$ . Theoretically, 42 percent  $\text{MnO}_2$  and 48 percent MnO. Sixty-nine percent manganese when pure. The color varies from steel-gray to iron-black, with a sub-metallic luster. H., 6 to 6.5, commonly too hard to scratch with a knife; G., 4.75 to 4.82. Never occurs in the pure form in nature; it is invariably associated with silica, either mechanically mixed or chemically combined. Recent work indicates that all braunites contain  $\text{B}_2\text{O}_3$  in amounts up to 1.2 percent. It is nearly always associated with other manganese minerals, such as any or all of the foregoing. It may sometimes be primary, although it is usually secondary. In veins or lenses it results from metamorphism of manganese oxides and silicates. With psilomelane, pyrolusite, and wad it occurs as a product of weathering. It is found in most of the Indian deposits, as well as at Miguel Burnier in Brazil.

Rhodochrosite:  $\text{MnCO}_3$ , 47.6 percent manganese when pure. Color is rose-pink to dark red or even brown; luster, pearly. H., 3.5 to 4.5, hence, easily scratched with a knife; G., 3.45 to 3.6. It usually occurs in cleavable masses to granular and compact masses, and as globules and crusts in veins. It is comparatively rare, being associated as a rule with other gangue minerals in copper, lead, zinc, etc., vein deposits. Found in deposits of sedimentary origin and in

metamorphic deposits that were derived from sediments. There are numerous scattered occurrences; at Butte, Mont., and in the French Pyrenees it has been mined as ore.

Rhodonite:  $\text{MnSiO}_3$  or  $\text{MnO} \cdot \text{SiO}_2$ , 41.9 percent manganese. It is usually a light brownish red, flesh-red or rose-pink, with a vitreous luster. H., 5.5 to 6.5; G., 3.4 to 3.68. Calcium evidently is always associated and may be an essential constituent in most cases. Its value is chiefly academic; it is sometimes used as an ornamental stone.

Bementite:  $2 \text{MnSiO}_3 \cdot \text{H}_2\text{O}$ , 39.1 percent manganese. Pale greyish-yellow to brown, with a pearly luster. It is soft and occurs in radiating masses resembling pyrophyllite, a form of soapstone (talc). G., 2.19. It has been mined in the Olympic Peninsula of Washington State.

There are, as noted, many more minerals of manganese. Those described are the only important ones. It bears mention here, however, that the two silicates, the carbonate and hausmannite, are of little more than secondary importance. Psilomelane, pyrolusite, wad, and braunite, it will be seen, are predominant to virtual exclusion of all other manganese minerals.

#### D. COMMERCIAL GRADES

Commercial ores of manganese are grouped in the trade into classes according to the chemical compositions needed for major end uses. These classes are related only indirectly to specific manganese minerals; an ore may consist of one or more minerals and further may be a blend of the products of several mines or pits. As often as not, a commercial ore has been improved in composition by cleaning and concentrating the run-of-mine material. The usual commercial classes are:

<u>Classes of ore</u>	<u>Content</u>
Chemical grade	82-87 percent $\text{MnO}_2$
Manganese ore	+ 35 percent manganese
Metallurgical (ferro) grade	+ 46 percent manganese
Ferruginous manganese ore	10-35 percent manganese
Manganiferous iron ore	5-10 percent manganese

Contract specifications for purchase of manganese ores are given in detail in another section of this report. Certain of the most important qualities, however, can be given here briefly, as follows:

For chemical and battery use, an ore should have a high content of oxygen available as  $MnO_2$ . Iron content should be low as should also be the silica and alumina contents. Arsenic, copper, lead, and phosphorus are objectionable impurities. Fine structure is probably preferred by most chemical users, since the ore is ground for processing.

For metallurgical use - that is, the making of ferromanganese - the manganese:iron ratio of the ore is very important. It is desirable to have this ratio 7:1 or more, since the production capacity of the plant is handicapped as this ratio drops. High silica is undesirable, because it makes more slag, thereby increasing the loss of manganese in the slag. Copper and zinc are objectionable impurities; the copper accumulates in the steel, while the zinc attacks the furnace linings. Small amounts of barite are tolerated. Lump structure is most desirable for metallurgical use, although certain modified furnaces can handle finer material satisfactorily.

Ferromanganese producers apparently prefer to blend commercial ores to their own specification in preparing their furnace charges. No single ore is generally considered as ideal and as a result consumers usually purchase ores from more than one source.

"Manganese ore" is a much broader term than those given above and refers to all ores and concentrates containing 35 or more percent manganese whether or not they meet battery, chemical, or metallurgical specifications.

Ferruginous manganese ores and manganiferous iron ores are classed progressively lower in manganese content.

## E. TYPES OF ORE DEPOSITS

### (General Discussion)

Manganese is found in a limited number of types of occurrence, of which but two are of leading importance. Bateman 2/ (1) lists the following modes of manganese occurrence:

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2/ Numerals in parentheses refer to the bibliography references at the end of the chapter.

### Kinds of deposits and origin

Hydrothermal deposits:	<u>Butte and Philipsburg, Mont. ;</u> <u>Leadville, Colo. ; Cuba</u>
Sedimentary deposits:	<u>Tchiaturi and Nikopol, Russia</u>
Residual concentrations:	<u>India, Gold Coast, Brazil,</u> <u>Egypt, Morocco</u>
Metamorphosed deposits:	<u>Postmasburg, South Africa; India;</u> <u>Olympic Mountains, Wash.</u>

\* Underlined deposits are the most important of their respective types.

Of these, the sedimentary and residual-type deposits are by far the commonest and largest. Metamorphosed deposits are next in importance; it will be noted that, in most instances, as in India, they were originally sedimentary deposits.

It has been shown that the oxides constitute ore minerals, almost to the exclusion of all others. Manganese ores are essentially mixtures of the various oxides and usually are secondary in origin.

Because it is active chemically, manganese not only occurs in a variety of forms (minerals); it is also easily extracted from those minerals in the oxide form and redeposited. Thus, primary mangani-ferous rocks become leached, and an enriched ore deposit results, either in place or at the place to which the manganese-rich solutions (generally colloidal) may be transported and precipitated. This, in brief, is the mode of origin of the sedimentary manganese deposits.

As is sometimes the case, it is not the manganese that is leached from the primary source rock, but rather, various undesirable elements. This can happen only under the proper physicochemical conditions, and when it does take place, a residual concentration results, as in the case of the Gold Coast deposits.

Manganese ores are not narrowly restricted as to geologic age; this applies to host rocks, source rocks, and actual times of formation of the ore deposits. The Russian sedimentary deposits are found in rocks of Eocene and Oligocene age (40 and 30 million years old, respectively, but very young, geologically speaking). Some of the Indian

deposits, on the other hand, are found in Archean rocks (something over 1 billion years of age and regarded even by geologists as quite old). Generally, the actual source rocks related to a manganese deposit are not known. It is believed, however that certain Indian deposits are found in the source rocks, as is the case in some Brazilian deposits. It is thought that the chemical processes that resulted in actual formation of manganese-ore deposits took place, in the majority of instances, in more or less recent geologic times. However, Fermor (2) considers certain Indian ores to have been originally deposited in pre-Cambrian time (over 500 million years ago) and that they have since been metamorphosed through the combined action of heat, pressure, and time.

The hydrothermal-type deposits bear brief mention before any discussion of specific occurrences. (The word "hydrothermal" refers to an ore deposit that was deposited from ascending (usually) hot water solutions. The source of both the heat and the water, as well as the dissolved mineral matter, is held to be deep within the earth's crust by most geologists.) These deposits are not restricted to any time period in geologic history. In the case of manganese they are generally associated with the acidic (that is, high-silica) igneous rocks. None of the known occurrences constitutes a major source of ore, either present or future. The real significance of this class of deposit is that it very likely provided the low-grade sources for most of the high-grade ores known today. Such is held to be the case, at any rate, in India, (3) Brazil, (4) Arkansas, (5) probably Russia and others.



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## II. RESERVES



## CHAPTER II. RESERVES

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## II. RESERVES

### A. ESTIMATES OF ORE AND MINERAL RESERVES

Mineral reserves are generally thought of as the amount of mineral-bearing material of a certain grade that remains in a deposit or area. If it is considered that the mineral or minerals can be extracted profitably, the unworked tonnage to which this applies is properly termed an ore reserve. The portion of such reserve that can be mined is called recoverable ore, and the portion of the mineral content that can be extracted is called the recoverable mineral or metal.

The size, tonnage, and grade of a mineral deposit can seldom be measured accurately. Mineral deposits lie in the ground; they may be visible in whole or in part in one dimension or possibly in two dimensions, but to find a deposit visible in its entirety in three dimensions would be most unusual. In addition, mineral deposits are seldom of uniform consistency or grade throughout and may have been displaced, distorted, or terminated by faults or other geologic processes not readily apparent. In determining their extent and quality, mineral deposits are tested at intervals by such means as drilling and sampling, which, in effect, are statistical procedures for obtaining data on which estimates may be based. Such an estimate, based on limited data, is necessarily approximate and a matter of judgment. In respect to mineral deposits, there is no standard of uniformity as to the amount of statistical data on which an estimate should be based. Some parts of a deposit are usually tested, as a matter of course, more thoroughly than other parts. Some deposits are merely inspected superficially. There is wide variation in the dependability of the information on which estimates are made; and unless the basis is clearly defined, an estimate may be subject to misinterpretation. Too often, the basis of an estimate is not defined clearly. This matter of variation in standards of dependability must be recognized in connection with any regional or worldwide tabulation of mineral resources, where many individual estimates are brought together as a group.

In view of the many uncertainties involved in estimating reserves, it has become customary among geologists and engineers engaged in this type of work to separate prospective ores into classes based on the relative dependability of the data from which the estimates were made. Separation into three such classes is common practice. "Proved ore," "probable ore," and "possible ore" are terms often used to express the relative assurances of these classes, although,

as will be noted below, there is no fixed terminology. Following are recognized examples of terms defined for purposes of ore and mineral estimation.

C. K. Leith, (1) in preparing estimates of iron-ore reserves, has defined terms used to designate respective classes of ore as follows:

"Assured" ore is defined to cover principally the ore blocked out in three dimensions by actual underground mining operations and drill holes, where the geological factors which limit the orebody are definitely known and where the chance of failure of the ore to reach these limits is so remote as not to be a factor in the practical planning of mine operations.

"Prospective" ore covers further extensions near at hand, where the conditions are such that ore will almost certainly be found but where the extent and limiting conditions cannot be so precisely defined.

Ore is classed as "possible" where the relation of the land to adjacent ore-bodies and to geological structures warrants the presumption that ore will be found but where the lack of exploration and development data precludes anything like certainty of its actual location or extent.

The Federal Bureau of Mines and the Federal Geological Survey, in recent estimates of mineral reserves, have agreed upon and defined (2) the following terms to signify relative dependability of information:

"Measured ore" is ore for which tonnage is computed from dimensions revealed in outcrops, trenches, workings, and drill holes and for which the grade is computed from the results of detailed sampling. The sites for inspection, sampling and measurement are so closely spaced and the geological character is so well defined that the size, shape, and mineral content are well established. The computed tonnage and grade are judged to be accurate within limits which are stated, and no such limit is judged to differ from the computed tonnage or grade by more than 20 percent.

"Indicated ore" is ore for which tonnage and grade are computed partly from specific measurements, samples, or production data and partly from projection for a reasonable distance on geologic evidence. The sites available for inspection, measurement, and sampling are too widely or otherwise inappropriately spaced to outline the ore completely or to establish its grade throughout.

"Inferred ore" is ore for which quantitative estimates are based largely on broad knowledge of the geologic character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geologic evidence; this evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geologic evidence of their presence. Estimates of inferred ore should include a statement of the special limits within which the inferred ore may lie.

These definitions of parallel terms are useful in helping to clarify the overlapping terminology in this field. Terms used in regional estimates will necessarily be defined somewhat less definitely than those used for a particular ore body.

## B. WORLD RESERVES - MANGANESE ORES

World reserves of high-grade manganese ores are of the order of 1, 000, 000, 000 tons of varying composition suitable either for direct shipment or for shipment as high-grade concentrates after beneficiation. Reported deposits in Ecuador and Uruguay are not included in this total for lack of confirmation; and the reserve tonnage included for the Postmasburg deposit, Union of South Africa, is but a fraction of some estimates. In addition to high-grade ores, there are known reserves of over 1, 000, 000, 000 tons of low-grade manganiferous materials, containing 3 to 10 percent manganese, mainly in the United States, from which it may be possible to obtain usable products, plus a further 2, 000, 000, 000 tons of 1 percent manganiferous material in the Chamberlain area, South Dakota. Neither of the above groups includes manganiferous iron ores, such as those of the Cuyuna range, or ferruginous manganese ores, such as those of Egypt, Czechoslovakia, etc., which are customarily used for their iron content but which command a premium in the trade in accord with their contained manganese. Reserves of manganiferous iron ores will be found included in iron-ore tabulations; the ferruginous manganese reserves

are minor in amount compared with true manganese ores, either high-grade or low-grade.

Estimates of reserves by individual countries are given in the accompanying table. This tabulation has been prepared by revising Kostov's (3) summary of 1940, the latest available, in the light of more recent information. Wherever a significant change from Kostov's estimate has seemed advisable, the new data will be found listed together with the reference or reasons for the change.

It is unfortunate that data are insufficient for reducing all of these individual world reserves accurately to their common denominator (namely, the recoverable manganese content), for then the respective deposits and reserves would stand out in their true light, and the reserves of one country could be compared with those of another on a uniform basis. But manganese is not unique in this respect; the same situation holds true for most metallic minerals, iron ore and chromite being typical instances.

Table II-1. WORLD RESERVES OF MANGANESE ORE - ESTIMATES BY COUNTRIES  
(Thousands of tons)

Sheet 1 of 5

Country	Kostov estimate, 1940		Current estimate		Remarks (data sources, reasons for revision, etc.)
	Reserves	Grade Mn percent	Reserves	Grade Mn percent	
North America					
Costa Rica	20	45	5 $\pm$	conc.	Geol. Survey Bull. 935-H, 1944.
Cuba	7,000	36-50 $\pm$	800-1,800	42-50 (conc.)	Geol. Survey current estimate.
Mexico	1,700	40 $\pm$	1,500	30-35	Geol. Survey Bull. 954-F, 1948.
Panama	150	50	50 $\pm$	30-50	Extent of intermediate-grade deposits not clear.
Puerto Rico	---	48-51	---	48 $\pm$	Reserves not clear; indications small.
United States					
Low-grade	415,000	3-10	800,000 $\pm$	3-10 $\pm$	Geol. Survey and Bureau of Mines; excludes Chamberlain, S. Dak.
Intermediate- grade	---	---	6,000	18-35	Geol. Survey and Bureau of Mines, mainly Montana oxide and carbonate ores.
High-grade	3,500	35 $\pm$	1,000	$\pm$ 35	Geol. Survey and Bureau of Mines; numerous small deposits.
South America					
Argentina	---	36-38	small	50 $\pm$	Numerous small deposits; nothing important.
Bolivia	---	50	---	---	No deposits reported to date; eastern area favorable geologi- cally; not well explored.
Brazil	30,000	38-50	60,000 $\pm$	38-50	Geol. Survey, 1949; Leao, J., 1938, Teixeira E. A., 1942, current press report on Amapa January 1951.
Chile	1,200	40-50	1,200	35 $\pm$	Benitez, G., 1941.

WORLD RESERVES OF MANGANESE ORE - ESTIMATES BY COUNTRIES  
(Thousands of tons)

Sheet 2 of 5

Country	Kostov estimate, 1940		Current estimate		Remarks (Data sources, reasons for revision, etc.)
	Reserves	Grade Mn percent	Reserves	Grade Mn percent	
South America - (Cont'd.)					
Ecuador	120,000	54	Questionable	---	No reserves proved; references vague; no firm data.
Uruguay	80,000	23	Questionable	21	No apparent economic interest, though deposits known of for many years.
Africa					
Angola	---	---	200	50 $\frac{+}{-}$	Estimate based on trade reports. Current estimate; additional reserves in Malonga area likely.
Belgian Congo	850	56	2,000	---	Strictly should not be classed as manganese ore; reserves 9,000 $\frac{+}{-}$ .
Egypt	12,000	32	---	Ferruginous manganese	Ghedem deposits not yet fully explored; indication small to date.
Eritrea	---	---	----	---	Production assumed offset by development.
French Morocco	47,400	40-50	47,400 $\frac{+}{-}$	40-50	Over 10,000 proved ore, Nsuta only; additional reserves likely.
Gold Coast	10,000	50 $\frac{+}{-}$	12,000	50 $\frac{+}{-}$	Recent discoveries not yet appraised.
Southwest Africa	---	---	---	---	Postmasburg deposit very extensive, variously estimated up to 1,000,000 potential.
Union of S. Africa	3,200	30-51	60,000 $\frac{+}{-}$	30-54	
Palestine	500	30	---	---	
Europe					
Bulgaria	---	30-45	100 $\frac{+}{-}$	20-60	Bureau of Mines For. Min. Survey, vol. 1, No. 9, September 1944.
Czechoslovakia	4,500	19-20	---	Ferruginous manganese	Strictly should not be classed as manganese ore; reserves 4 500 $\frac{+}{-}$ .

WORLD RESERVES OF MANGANESE ORE - ESTIMATES BY COUNTRIES  
(Thousands of tons)

Sheet 3 of 5

Country	Kostov estimate, 1940		Current estimate		Remarks (Data sources, reasons for revision, etc.)
	Reserves	Grade Mn percent	Reserves	Grade Mn percent	
Europe - (Cont'd.)					
Germany	250, 400	4	250, 000 $\frac{+}{-}$	4	Numerous small deposits. Not including intermediate-grade deposits reported at 6, 000 reserves, 8-20% Mn content. Deposits generally small. References vague; no firm data; no production reported. Reserves of manganeseiferous iron ore, 2-35% Mn, reported at 10, 000.
Low-grade	5, 600	15-20	5, 000 $\frac{+}{-}$	15-20	
High-grade	---	30 $\frac{+}{-}$	400	30 $\frac{+}{-}$	
Greece	---	35-48	4, 500	435	
Hungary	---				
Italy	500	34-37	500 $\frac{+}{-}$	34-37	1943 estimate less production. Large reserves manganeseiferous iron; 2-11% Mn. Manganese mainly byproduct, Langban mine. Betekhtin estimate 1935, less prod., plus new reserves 1935-49. Little activity recent years.
Poland	10, 000	35	Questionable	---	
Portugal	---	40 $\frac{+}{-}$	---	---	
Rumania	9, 000	30-36	7 200	14-40	
Spain	---	31-34	Moderate	---	18, 000 high-grade, 38-52% Mn, balance lower. Little development to date.
Sweden	---	30-50	Moderate	30-50	
U. S. S. R.	652, 400	41-48	625, 000	20-50	
Yugoslavia	480	32-38	480 $\frac{+}{-}$	35 $\frac{+}{-}$	
Asia					
China	22, 000	45-46	29, 000	20-50	
Formosa	400	---	400	---	

Country	Kostov estimate, 1940		Current estimate		Remarks (Data sources, reasons for revision, etc.)
	Reserves	Grade Mn percent	Reserves	Grade Mn percent	
Asia - (Cont'd.)					
Goa (Port. India)	---	42-50	Small	---	Numerous small deposits; lateritic. Shipments replaced by new discoveries.
India	92,000	47-52	92,000 $\frac{+}{-}$	47-52	One operating mine; reserve data lacking.
Indochina	---	---	---	---	No major exploration or development to date.
Indonesia	10,000	50-55	10,000	50-55	Numerous deposits; none considered large.
Japan	---	49-51	2,000	---	Reported depleted.
Malaya (British)	80	30	---	---	Bureau of Mines, For. Min.
Manchuria	10,000	---	3,000	-30	Survey, vol. 2, No. 7, 1948.
Philippines, Republic of	1,500	45-50	6,000	+35	Numerous deposits; estimates range to over 10,000; estimate 1945, consular report.
Turkey	12,000	30-50	1,000 $\frac{+}{-}$	30-50	Confirmation lacking on Finike deposit; lower estimate more likely.
Oceania					
Australia	2,250	35	500	42-52	Excludes manganese iron ore at Iron Monarch.
New Zealand	50	45-50	15 $\frac{+}{-}$	45-50	Otau deposit; no others to date.
Papua	---	---	---	50 $\frac{+}{-}$	Indications small; limited exploration to date.



WORLD RESERVES OF MANGANESE ORE - ESTIMATES BY COUNTRIES  
(Thousands of tons)

Sheet 5 of 5

Country	Kostov estimate, 1940		Current estimate		Remarks (Data sources, reasons for revision, etc.)
	Reserves	Grade Mn percent	Reserves	Grade Mn percent	
World total High-and inter- mediate grades, as listed. Low-grade, as listed.			980,250  1,050,000		
World total - Rounded estimate including countries for which specific reserves not listed. High-and inter- mediate-grades. Mn ore Low-grade, Mn materials.			1,000,000 +  1,000,000 +		Excludes 2,000,000 reserve 1 percent manganese material, Chamberlain, S. Dak.

Table II-2. ESTIMATED MANGANESE CONTENT OF MAJOR WORLD RESERVES

(Millions of tons)

Country and deposit	Estimated ore reserve	Grade in percent Mn	Mn a/ metal content	Remarks
U.S.S.R.				
Nikopol	396	28-33	121	Except as noted, estimated reserves included all classes of ore.
Chiaturi	162	48-49	78	
Laba	33.9	17-24	7.1	
Mangyshlak	32.8	22	7.2	
India	92	47-52	46 $\frac{1}{2}$	Estimated, round numbers, for entire country.
Union of South Africa				
Postmasburg	60	37-52	27	Reserve estimate nominal. Average grade Taken 45% Mn.
Gold Coast				
Nsuta	*10 $\frac{1}{2}$	52	**5.2	*Proved ore only, after Dunn. **3.9 on concentrate basis.
Brazil				
Urucum	33.7	45.6	15.4	U.S.G.S. Bull. 946-A, 1945.
Amapa	*25 $\frac{1}{2}$	**51	12.8	*Current est., Eng. & Min. Jour., January, 1951, p.122. **U.S.G.S. Bull. 964-A, 1949.
U. S. A.				
Cuyuna Range, Minn.	500	5 $\frac{1}{2}$	26.7	To 1,400 foot depth, about 10% mineable by open pits. *Nodules only.
Aroostook County, Maine	330	7 $\frac{1}{2}$	24	
Chamberlain, S. Dak.	*77	*15.6	12	
Artillery Mountains, Ariz.	180	4	7.2	
Others			6.6	

a/ Calculated amounts; not necessarily recoverable and should be so recognized.

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### III. ORE SPECIFICATIONS





## CHAPTER III. ORE SPECIFICATIONS

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### III. ORE SPECIFICATIONS

#### A. MANGANESE-ORE SPECIFICATIONS AND USABILITY

##### United States Steel Company

R. M. Lloyd, vice president, Raw Materials, United States Steel Co., has outlined its considerations (1) in purchasing manganese ore as follows:

##### 1. Average Specifications Desired

In general, manganese ore for economical smelting to ferro-manganese should contain, on the average, about 48 percent metallic manganese by weight and about 6 percent metallic iron. The silica and alumina contents of the ore should be as low as possible and should not exceed a combined total of 11 percent. On the average, such ore should not contain more than 0.12 percent phosphorus. Other contaminations, such as zinc, tin, lead, and copper, even in small amounts, are deleterious, and the content of strong alkalies, such as sodium and potassium, should be practically nil. Ores with manganese as low as 40 percent can be used in mixtures with higher-grade ores provided a manganese:iron ratio of 7-1/2:1 or higher is maintained over all, and the slag-forming constituents are not excessive in the resulting mixture of ores as charged in the furnace.

For desirable physical characteristics, the maximum size of lumps in manganese ore should not exceed approximately 5 inches and the content of very small particles, less than No. 20 mesh size, should be limited. In the case of dense granular ores the fines content should be restricted to 7 percent through a No. 20 mesh screen and the fines content of more porous ores should be limited to about 10 percent through a No. 14 mesh screen with not more than 5 percent smaller than No. 20 mesh.

##### 2. Characteristics of Indian, African, and Brazilian Ores Used

With regard to the chemical and physical characteristics of manganese ore from foreign sources, the principal ores used by United States Steel are:

Indian ore, which contains approximately 49 percent manganese and 8 percent iron. Combined silica and alumina

10 percent and other impurities are low. Physically, this ore has been found to be well-adapted to blast-furnace ferromanganese production; the representative sizing is 85 percent over one-half inch with 5 percent or less smaller than No. 20 mesh screen.

South African ore, which contains 40 to 50 percent dry manganese and 10 to 15 percent iron. The low silica content of this ore, 2.5 to 3 percent, makes it satisfactory for mixtures with higher-silica ores. Physically, this ore is dense and hard; approximately 75 percent is over 1-inch size, and only a very minor percentage is fine material.

Brazilian ore, which contains about 45 percent dry manganese and 4.5 percent iron. Combined silica and alumina approximate 12 percent and other impurities are low. Physically, this ore is well-adapted to ferromanganese production, about 65 percent being material larger than one-half inch and about 5 percent being minus No. 20 mesh screen size.

### 3. Inventory and Blending of Manganese Ores; Ferromanganese Production and Foreign Holdings

Since these are the major sources of United States Steel's manganese-ore supply, continuity of ferromanganese production and supply is dependent upon ores which must be transported by foreign railroads and by vessels over great distances. For this reason, large stocks approximating a year's supply are desirable to maintain a constant manganese supply in the face of the innumerable possibilities of interruption which may occur in production, in foreign rail movements, in foreign port operations, and in vessel movements due to many contingencies, including labor, civil, and governmental interruptions.

When ores are received at consuming points, they are stockpiled separately by grades for use. No attempt is made to blend the ores from various sources before charging into the blast furnaces. The various ores are charged as separate grades into the blast furnaces in the proportions over a given period of hours, with respect to chemical and physical properties, which will produce the desired grade of ferromanganese. In general, any single grade of manganese ore, when used alone, does not have the desirable average chemical and physical characteristics for blast furnace ferromanganese production which are secured by charging several different ores.

Together with the foreign ores in blast-furnace mixtures, a portion of domestic ores also is charged. Nodulized manganese ore

produced by Anaconda Copper Mining Co. is the only large source of domestic manganese ore at this time, and this material has constituted about 18 percent of the total manganese charged in recent years by the subsidiaries of United States Steel. When available, tonnages of other suitable domestic natural ores and concentrates have been used, but such other ores have not constituted more than a very minor part of the annual supply since the First World War. For a period during World War I, because of shipping interruptions the principal supply of manganese was limited to domestic ores. The major portion of these ores was unsatisfactory due to erratic chemical and physical qualities which reflected low blast-furnace production, high manganese losses, high production costs, and substandard ferromanganese.

United States Steel's production of ferromanganese is limited to the high-carbon grade since production is entirely in blast furnaces. This process is not adaptable to the production of other grades.

Of the total ferromanganese produced by United States Steel's subsidiaries in recent years, about 20 percent has been produced from domestic ores.

The subsidiaries of United States Steel have no domestic manganese-ore holdings. A Brazilian subsidiary, controlled through stock ownership and having its own reserves, produces about 30 percent of United States Steel's annual requirements.

## B. STANDARDS FOR PURCHASE AND USE OF MANGANESE ORE

### Sloss-Sheffield Steel & Iron Co.

R. E. Garrett, executive assistant, Sloss-Sheffield Steel & Iron Co., Birmingham, Ala., has outlined (2) its standards for purchase and use of manganese ore as follows:

Acceptable specifications of metallurgical-grade manganese ore for standard-grade ferromanganese:

Manganese - - - - -	48 percent minimum
Iron - - - - -	6 percent maximum
SiO <sub>2</sub> - - - - -	6 percent maximum
Al <sub>2</sub> O <sub>3</sub> - - - - -	4 percent maximum
Phosphorus - - - - -	0.12 percent maximum
Lead, zinc, arsenic, etc. - - - -	Traces



Cuban ore: Desirable qualities: Iron and phosphorus contents low, silica content fairly low. Can be blended with ores of relatively high iron and phosphorus contents to produce standard-grade ferromanganese. Undesirable qualities: Manganese content low; extremely fine, does not work well unless blended with lumpy ores.

The Indian ores are generally higher in grade than others, but they also carry considerably more iron, so it is necessary that we buy other ores and blend them in our furnaces. We can do that blending when we have large piles of each particular type. We cannot blend individual cars or individual small lots satisfactorily, because we are a commercial producer of ferromanganese and we must meet the standard of 78 to 82 percent manganese. We cannot do it using lower-grade ores.

### C. SPECIFICATIONS AND ANALYSIS OF MANGANESE ORE USED

#### Bethlehem Steel Co.

I. D. Simms, assistant purchasing agent, Bethlehem Steel Co., has given its views (3) on manganese ore as:

#### 1. Acceptable Specifications

While it is difficult to give a general specification entirely satisfactory for all applications of manganese ore consumption, the specification now being used by the Army and Navy Munitions Board as follows.

	Percent
Mn (minimum) . . . . .	40.00
Fe (maximum) . . . . .	14.00
Mn:Fe ratio (minimum) . . . . .	3.50
SiO <sub>2</sub> + Al <sub>2</sub> O <sub>3</sub> (maximum) . . . . .	15.00
P (maximum) . . . . .	.18
Cu + Pb + Zn (maximum) . . . . .	.50

Purchases to be restricted so as to maintain in stockpile the following minimum average quality:

	Percent
Mn (minimum) . . . . .	48.00
Fe (maximum) . . . . .	6.00
SiO <sub>2</sub> + Al <sub>2</sub> O <sub>3</sub> (maximum) . . . . .	12.00
P (maximum) . . . . .	.12
Cu + Pb + Zn (maximum) . . . . .	.10

The strict adherence to, or relaxation from this specification may be dependent on the quantity and quality of ore in stockpile and purchased.

## 2. Characteristics of Various Ores

Differences in physical and chemical characteristics of ores--  
typical chemical analysis and physical condition of various ores:

Table III - 2. TYPICAL ANALYSIS, PERCENT  
AND PHYSICAL CONDITION, PERCENT

	Russian	Indian	South African (first- grade)	Gold Coast	Chilean	Brazil- ian	Montana manga- nese nodules
Mn (dry)	50.00	50.00	49.00	46.00	48.50	45.00	60.00
Fe (dry)	.75	6.50	9.00	5.00	.75	5.00	3.00
SiO <sub>2</sub> (dry)	10.00	7.85	3.50	5.00	11.00	7.50	8.00
Al <sub>2</sub> O <sub>3</sub> (dry)	2.00	1.75	3.75	4.00	2.00	7.50	.75
P	.175	.12	.05	.12	.02	.10	.05
Moisture (natural)	6.75	.73	.43	5.50	1.50	10.50	.25

## PHYSICAL CONDITION, PERCENT

Screen sizes on:							
4-inch	0	15	8	0	0	3-1/2	1
3-inch	0	12-1/2	13	0	0	1	18-1/2
		16-1/2	20	1/2	1	5	20
			32	5	49	6	10
			12	26-1/2	19	7-1/2	10
			7	30	7	40	--
			1	8	3	3-1/2	4
			1	5	3	1-1/2	2-1/2
			1/2	1-1/2	4	1/4	2-1/4
			1/4	1/4	2	--	1
			1/2	1-1/2	3	--	3



#### D. BATTERY-ORE SPECIFICATIONS

The battery industry has long admitted that the methods of determining a satisfactory battery ore are not completely effectual. It has been known that manganese dioxide is required but also that all ores high in  $\text{MnO}_2$  did not give the same results when made up into a battery. Some ores that are high in  $\text{MnO}_2$  content (80 to 90 percent) do not perform as well in batteries as ores of low  $\text{MnO}_2$  content (60 to 65 percent). For this reason, it has been obvious that mere chemical analysis, which found the amounts of  $\text{MnO}_2$  and of impurities in the form of other metals, is not a reliable method of determination. For years, the best method of selecting good battery-grade ore has been to make up test cells from samples of various ores and then test the characteristics of these sample cells over a period of time.

The need for a better means of identifying a good battery ore has been made apparent for two reasons. First, if it is known what constitutes a superior ore, progress can be made toward discovering new high-quality natural ores and producing good artificial ores. Second, the time lag necessary in the present testing procedure does not lend itself to the pressure of normal business, much less to emergency conditions.

In the light of the relatively uncertain standards for a good battery ore, much research has been carried on in recent years by those institutions interested in the industry, namely the battery manufacturer, the E. J. Lavino Co., representing ore suppliers, and the Signal Corps of the United States Army, representing consumers.

The summation of the testing techniques developed reveals three new investigational methods: (a) Differential thermal analysis; (b) x-ray analysis; (c) electron-microscopic analysis. As a result of application of these techniques, it has been determined that there are several phases of  $\text{MnO}_2$ , identified as alpha, beta, gamma, delta, epsilon, ramsdellite, and pyrolusite. Both pyrolusite and ramsdellite occur as natural ores and seem to be limited to well-crystallized materials which give sharp x-ray diffraction patterns. The terminology of these minerals is not clear at present, and there is divergence of opinion as to the boundary lines of the phases. In general it is assumed that a good ore is one that is well-crystallized in fine crystals that offer a large surface.

Using what are now considered the best data, the Signal Corps has drawn up what it terms "tentative specifications" for manganese

dioxide of military battery grade, both natural and synthetic. The chemical composition of these specifications is as follows:

Table III - 3. CHEMICAL COMPOSITION

	<u>Natural</u>	<u>Synthetic</u>
Available oxygen as % MnO <sub>2</sub>	75% min.	85% min.
Total manganese as % Mn	48% min.	58% min.
Absorbed moisture of % H <sub>2</sub> O	5 % max.	3% max.
Iron as % Fe (soluble HCl)	3% max.	0.2% max.
Silicon as % SiO <sub>2</sub>	5% max.	0.5% max.
Metallic impurities (Cu, Cd, Ni, Pb, Sb, etc.)	0.2% max.	0.1% max.
pH	4.0-8.5	4.0-8.0

In addition to the above chemical analysis, specifications for microscopic crystalline structure and for x-ray diffraction patterns are given calling for a predominance of the phase known as gamma MnO<sub>2</sub>.

The indeterminate status of present techniques is pointed up by the following quotation from the Signal Corps Specification:

In Inasmuch as an evaluation of each sample is required in not more than 1 month's time, the evaluation must of necessity be based upon initial capacity tests only. However, in order to prove each evaluation, sufficient dry cells are made from each sample, as previously described in 4.4.1 and 4.5.1, and set aside for delayed capacity tests after storage periods of 3.6, 12.18 and 24 months at a temperature of 70° F. (4)

The indication seems to be that the problem of what constitutes a good battery ore has not been completely solved but that enough progress has been made so that certain factors can be assumed to be determinable and can provide a fairly reliable index. Research is continuing, and it is hoped that eventually the point will be reached where the unknown factors will have been brought to light.

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#### IV. STOCKPILING





## CHAPTER IV. STOCKPILING

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#### IV. STOCKPILING

Manganese ore of ferro grade has been considered a strategic mineral since 1916, when the Council of National Defense was first established by the Congress to aid in "coordination of industries and resources for national security and welfare." The first official list of strategic materials was drawn up in 1921 by a committee headed by General Harbord and was called the Harbord List. Ferro-grade manganese ore was among the 18 minerals and metals on the list and was specified as of concern to two or more branches of the military service, thus placing manganese among the most critical to one third of the group. In all subsequent lists, prepared periodically by the Army and Navy Munitions Board and, since World War II, by the Munitions Board, manganese has been included as strategic, or strategic and critical.

Following are Material Purchase Specifications for the three grades of manganese ore in effect during 1951:

29 June 1950  
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#### NATIONAL STOCKPILE

#### MATERIAL PURCHASE SPECIFICATION

##### A. MANGANESE ORE - METALLURGICAL GRADE

#### 1. DESCRIPTION

This specification covers manganese ore suitable for the manufacture of commercial grades of ferromanganese and special manganese alloys, and for the production of those chemicals which do not require the use of ore of high manganese dioxide content.

#### 2. CHEMICAL AND PHYSICAL REQUIREMENTS

##### a. Chemical Requirements:

Each proposal to sell shall set forth the chemical analysis limits which the seller is willing to guarantee. These will become the rejection limits for material delivered against a resulting contract. Each delivery against such contract need not meet these rejection limits but the weighted average of all deliveries shall meet such limits.

Offers will not be considered unless the proposed chemical analysis limits are at least within the following in all respects:

<u>By weight (dry basis)</u>		
Manganese	(Mn)	40.0 % Min.
Iron	(Fe)	6.0 % Max.
Silica plus alumina	(SiO <sub>2</sub> plus Al <sub>2</sub> O <sub>3</sub> )	15.0 % Max.
Phosphorus	(P)	.30% Max.
Copper plus lead plus zinc	(Cu plus Pb plus Zn)	1.00% Max. *

\* Of which not more than 0.25% may be copper.

Guaranteed analyses superior to that stated above are desired and the right is reserved to reject any proposal concerning which the proposed guaranteed analysis is inferior to the following:

<u>By weight (dry basis)</u>		
Manganese	(Mn)	46.0 % Min.
Iron	(Fe)	8.0 % Max.
Silica plus alumina	(SiO <sub>2</sub> plus Al <sub>2</sub> O <sub>3</sub> )	12.0 % Max.
Phosphorus	(P)	.18% Max.
Copper plus lead plus zinc	(Cu plus Pb plus Zn)	.10% Max.

Each bidder should, in the interest of having his bid accepted, offer the best chemical analysis limits which he is prepared to accept as rejection limits on a weighted average basis.

**b. Physical Requirements:**

Three types of material, according to physical characteristics, are covered by this specification. All offers shall stipulate the type covered and the following shall constitute the rejection limits for each type.

Type I, Lumpy Ore - shall be natural ore, unprocessed except for grading, washing or screening. Not more than 5% shall pass a Tyler standard 20 mesh screen.

Type II, Fine Ore - shall be natural ore, unprocessed except for grading, washing or screening. No more than 15% shall pass a Tyler standard 20 mesh screen.

Type III. Nodules or Sinter - shall be natural fines, or concentrates, densely agglomerated by the application of heat. Not more than 5% shall pass a Tyler standard 20 mesh screen.

Type I material is preferred.

The above physical specifications shall apply to the weighted average of all material delivered against a contract. Individual shipments which fall outside the requirements will be treated as detailed under Paragraph 2a for shipments falling outside chemical limits.

18 April 1950

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## NATIONAL STOCKPILE

### MATERIAL PURCHASE SPECIFICATIONS

#### B. MANGANESE ORE - CHEMICAL GRADE

##### 1. DESCRIPTION

This specification covers high-dioxide manganese ore of two types:

Type A - suitable for use as an oxidizing agent in chemical processes, such as in the manufacture of hydroquinone.

Type B - suitable for the production of potassium permanganate and other permanganate chemicals.

Ores of Type A are known to occur in the Caucasus, Java, French Morocco, and Cuba. Ores of Type B are generally found in the African Gold Coast and may also originate in Java and some parts of Cuba. This does not preclude the offering and consideration of ore of other geographical origin, provided it meets the specifications.

## 2. CHEMICAL, MINERALOGICAL AND PHYSICAL REQUIREMENTS

### a. Chemical Requirements:

<u>Type A Ore</u>	<u>% by Weight, Dry Basis</u>
Manganese dioxide ( $\text{MnO}_2$ )	80.0 Minimum
Iron (Fe)	3.0 Maximum

### Type B Ore

Manganese dioxide ( $\text{MnO}_2$ )	85.0 Minimum
Iron (Fe)	3.0 Maximum
Silica ( $\text{SiO}_2$ )	3.0 Maximum
Alumina ( $\text{Al}_2\text{O}_3$ )	3.0 Maximum
Phosphorus	.10 Maximum
Arsenic	.05 Maximum

### b. Mineralogical Requirements (for Type A ore only):

Upon x-ray examination of the Type A ore, there shall be evidence of the predominance of pyrolusite.

### c. Physical Requirements:

Ore must be either in its natural state or in the form of concentrates. It shall not have been finely ground or pulverized for use by the chemical industry.

## 3. PACKAGING

Material shall be supplied in bulk. The origin of each lot shall be identified by:

- (1) Nation, province and district.
- (2) Individual mine or deposit.

## 4. INSPECTION

Material shall be subject to inspection and analysis by the purchaser or its designee for conformance with all requirements of this specification and to make sure that it is suitable for use for the purpose named in paragraph 1 hereof.

ARMY AND NAVY MUNITIONS BOARD  
Washington, D. C.

MATERIAL PURCHASE SPECIFICATIONS

C. MANGANESE ORE-BATTERY GRADE

1. DESCRIPTION

This specification covers high-manganese-dioxide ore, sometimes referred to as black manganese ore, suitable for the production of dry cell batteries and certain chemicals. The specification refers particularly to ore originating in the Gold Coast Colony and in the Phillipsburg District of the State of Montana. This does not preclude the offering and consideration of ore of other origin.

2. CHEMICAL, PHYSICAL, AND OTHER REQUIREMENTS

a. Chemical Requirements:

Each lot of Gold Coast or Phillipsburg ore shall conform to the following:

				<u>% by Weight, Dry Basis</u>	
				<u>Gold Coast</u>	<u>Phillipsburg</u>
Manganese Dioxide (MnO <sub>2</sub> )	Min.			84.00	68.00
Iron	(Fe)	Max.		2.00	2.50
Lead	(Pb)	Max.			.50
Arsenic	(As)	Max.			.10
Copper	(Cu)	Max.			.03

Chemical requirements for ore of other origin will be determined at the time of offer.

b. Physical Requirements:

Ore may be either in its natural state or in the form of concentrates. It shall not have been pulverized for use in the manufacture of batteries.

c. Other Requirements:

Each lot of ore, regardless of source, shall be suitable for the manufacture of dry cell batteries of current standard commercial quality, by the existing commercial processes. Failure to meet this requirement shall be cause for rejection, regardless of chemical analysis.

3. PACKAGING

Material shall be supplied in bulk. Each lot shall be identified as to its origin by:

- (1) Country, State, or Territory,
- (2) District,
- (3) Individual mine or deposit.

4. INSPECTION

Material shall be subject to inspection and analysis by the purchaser or its designee for conformance with all requirements of this specification, including the requirements of Paragraph 2c.

29 June 1950  
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NATIONAL STOCKPILE

MATERIALS PURCHASE SPECIFICATION

D. FERROMANGANESE

1. DESCRIPTION

This specification covers commercial standard ferromanganese suitable for the manufacture of iron and steel.

2. CHEMICAL AND PHYSICAL REQUIREMENTS

a. Chemical Requirements:

Ferromanganese shall meet the following chemical requirements:



		<u>Percent</u>
Manganese	Minimum	75.00
Carbon	Maximum	7.50
Silicon	Maximum	1.25
Phosphorus	Maximum	.35
Sulfur	Maximum	.05
Iron		Remainder

b. Physical Requirements:

Ferromanganese shall be furnished in lump form, preferably four inches or larger.

3. PACKAGING

Material shall be supplied in bulk.







## V. MINING DRESSING AND BENIFICATION



## CHAPTER V. MINERAL DRESSING AND BENEFICATION

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## V. MINERAL DRESSING AND BENEFICIATION

### A. SUMMARY

Most manganese ores as found in the natural state require some one or more forms of dressing before being used.

Although there are many variations of types of equipment used for the purpose of preparing ores for use, the types of procedures are grouped as:

1. Hand sorting.
2. Crushing.
3. Scrubbing and washing.
4. Screening.
5. Grinding.
6. Wet classification.
7. Sink-float separation.
8. Jigging and shaking.
9. Flotation.
10. Dewatering.
11. Magnetic separation and roasting.
12. Dust collection.
13. Open-air ground storage.

Different ores require the use of different combinations of the above and the amount of work put on any one type of ore is generally dictated by economic considerations. A report by F. D. DeVaney is included as an appendix to this chapter to demonstrate possible uses of the various processes on domestic low-grade ores.

### B. HAND SORTING

Hand sorting has a somewhat limited application in high-labor-cost areas but may be used extensively in low-cost areas. The process involves passage of the material before a group of pickers or sorters, who manually or mechanically remove some portion and in so doing effect a separation. For hand sorting to be used, it must be possible to distinguish by sight the deleterious material, and the separated product must be of a size to permit ease of handling.

## C. CRUSHING

Crushing is a mechanical operation in which enough force is applied to relatively brittle solid particles to produce failure of the bonding surfaces. Such force may be produced by reciprocating action of the crushing surfaces, which alternately approach and withdraw from each other, by continuous movement of the crushing surfaces toward a predetermined minimum opening, or by creating an impact between high-velocity particles and a stationary surface.

Certain types of crushing equipment are more useful than others determined by the material used and the desired product. Jaw and gyratory crushers are best-adapted to reducing hard, tough, abrasive rock, while hammer mills and a roll-type crushers reduce soft friable or sticky material. Where a granular product with a minimum of fines is desired, crushers that apply a steady, continuous pressure are used. If fines are not detrimental in the product, the impact type of mechanism may be applied, or the discharge may be restricted, keeping the material in the crushing zone for a longer period.

## D. SCRUBBING AND WASHING

Scrubbing and washing separate loams, clays, and fine sands from a granular product. Separation is induced by tumbling the material in a liquid medium; the finer materials are carried off in the liquid, while the granular product is left behind to be removed by gravity or some mechanical means.

## E. SCREENING

Screening is a process of grading a mixture of particles by size, accomplished by bringing each particle into contact with an opening of a predetermined size and shape. Particles that pass through the openings are called the undersize and those remaining on the screen the oversize.

The purposes of screening generally are: (a) To separate the fines; (b) to separate the coarser sizes for further reduction; (c) to grade products to the desired size; and (d) to perform a concentration function.

Gravity are both used in various  
erial over the surface of the  
ary. By varying these factors,

many methods of screening may be evolved, dependent upon the material to be screened and the product desired.

## F. GRINDING

Grinding is accomplished by means of pressure and abrasion. The working surfaces of a grinding mechanism must touch, in so far as possible, the material being processed to provide a means of applying compression and shear.

The purpose of grinding varies with the type of material being processed. Mechanical liberation of the valuable portion from the gangue may be most important; however, further grinding, with a consequent reduction in size, may be necessary to facilitate movement in a later process, such as flotation. The production of surface may be desirable if reaction with a chemical is anticipated.

Grinding may be accomplished either wet or dry, determined by various factors: (a) Use of the product; (b) effect of the material on the mill; (c) characteristics of the particle produced; (d) economy; (e) climatic conditions; (f) availability of water; and (g) safety, speed, etc.

## G. WET CLASSIFICATION

Wet classification is a process in which separation is accomplished by using different settling rates of particles in a fluid medium, as determined by the difference in specific gravity and size of the particles.

Some classifiers separate the slimes from the granular portion of material, while others perform an additional function of classifying the solids as well.

In some applications, dry classification may be used, in which air is substituted for the liquid medium; however, the same basic principles of separation apply.

## H. SINK-FLOAT SEPARATION

Sink-float separation is based on the fact that finely divided particles suspended in a solution raise the specific gravity and the viscosity of the solution. Such a solution may be likened to a quicksand of controlled specific gravity and viscosity which will float or sink

various substances on the basis of their different specific gravities.

This process permits separation to take place, the products being removed from the surface and the bottom of the medium.

## I. JIGGING AND SHAKING TABLES

Jigging and shaking tables are a means of concentration employing the difference in specific gravity of particles to effect separation. Generally the particles are subjected to the force of gravity and one or more other forces to produce a difference in movement.

Jigging employs a box into which the material is introduced and stratifies owing to the mechanical motion of the apparatus, which makes possible removal of the different layers of material at separate points of the discharge area.

Shaking tables produce a similar separation by allowing the material to move across a plane surface broken by a series of riffles or cleats. This surface is given a shaking motion and is usually washed by a current of water running at right angles to the direction of the cleats; thus the lighter product tends to move in the direction of the water flow, while the heavier particles tend to follow the direction of the cleats, providing different discharge points or areas for the different products.

## J. FLOTATION

Flotation is a process that involves treatment of a finely divided material so that certain particles attract air bubbles which adhere to their surface while other particles do not attract or repel air bubbles. When the treated material is introduced into a liquid medium, they assume different specific gravities owing to the attraction or repellence of air bubbles. This difference may cause the particles to either float or sink or to follow a different path of travel in some sort of mechanical separator, which allows their final separation.

## K. DEWATERING

Dewatering applies to separation of water and solids. Perhaps the simplest form of dewatering is draining, which may be applied when the solid particles are fairly large. Sedimentation and thickening employ the settling action of solids when water is allowed to come to

rest. Filtration is applied when particles are so small as not to be recovered by settling. When complete removal of water is necessary, drying may be used. Since drying is relatively expensive, the greater part of the water is removed previously.

#### L. MAGNETIC SEPARATION AND ROASTING

Magnetic separation utilizes the force of a magnetic field along with the action of some mechanical force to cause a differential motion of the particles. Primarily the success of magnetic separation depends on the relative difference of the magnetic permeability of the particles; however, size, specific gravity, and purity of the particle have a practical effect on the process.

Certain minerals as found in nature have very low or no magnetic permeability and as such are not amenable to magnetic separation. Through a process of roasting, some of these ores may be changed from their original chemical composition to a new compound of higher magnetic qualities. Roasting therefore often is associated with the process of magnetic separation.

#### M. DUST COLLECTION

Dust collection is the removal of finely divided particles of solid from gases. Methods of collection are: (a) Gravitational or settling chambers, (b) inertial separators that employ baffles or centrifugal force, (c) filters of which the bag type is typical, (d) washers in which water sprays are used, and (e) electrical precipitators, of which Cottrell are possibly the best-known. The above types more or less inherently handle different sizes of dust particles; thus the choice of equipment is based largely on the individual problem.

#### N. OPEN AIR GROUND STORAGE

Stockpiling - open air storage on the ground - may be used when the material is bulky, reasonably cheap, and unaffected by weather. Segregation by grades of material may be necessary and presupposes a planned program of space allocation. Certain segregation according to size may also be desired; however, in individual stacks or piles a certain amount of size segregation occurs naturally owing to the tendency for the large lumps to roll down the pile and accumulate at the base or periphery of the pile while the finer sizes tend to pack at the top and center. To avoid this natural segregation, the size ratio of the stock of any pile should not exceed 2:1.

three classes: (a) The material may be dumped on the ground level and then raised to the pile by means of clamshell cranes, belt conveyors, or traveling bridges; (b) material may be dumped on the ground and pushed into piles by means of cable or drag scrapers or bulldozers; or (c) the original delivering unit may be raised to the top of the pile or a trestle and dumped from above.

Material may be reclaimed from stockpiles by means of: (a) Power shovels, clamshells, and traveling bridges; (b) belt-conveyor systems; and (c) scrapers and bulldozers, usually in conjunction with some type of flight elevator system.

As may be readily seen, a well-designed lay-out of stockpiling will make as much use of the mechanical equipment as possible through integration of both the building and reclaiming functions into the same components of the system.

## O. APPENDIX

### RECOVERY OF FERROMANGANESE-GRADE ORE FROM SMALL ORE DEPOSITS

#### Batesville - Cushman, Ark.

Manganese occurs in several different forms of deposits in this district which is roughly 20 miles long and 5 miles wide. This district is, at present, being examined and prospected by Geological Survey and Bureau of Mines staff members.

#### Lump Ore

Hand-picked from clay. Manganese minerals are hausmannite, braunite, and psilomelane. Such ores contain 42 to 58 percent Mn, about 5 percent Fe, 3 to 10 percent  $\text{SiO}_2$ , and 0.08 to 0.25 percent P. Deposits are spotty, and attempts at machine mining have failed. Price increase will bring out more ore; and in time of emergency the district probably could produce 15,000 tons annually. Ore of this type is no milling problem, and the question is one of ore reserves and mining.

### Wad Ores

Material being shipped contains about 30 percent Mn, 10 percent insolubles, 25 percent moisture and 0.5 to 1.5 percent P. Such ores are log-washer concentrate. There is no hope for grading this material up to ferro grade by gravity or flotation ore-dressing processes because of high phosphorus. It is, however, excellent raw material for a leaching and electrolytic manganese plant, since the ore is porous and easily roasted and leached. If need arises for wad-type ores, a central log-washing plant, together with a nodulizing plant for drying out the moisture from the ore and improving its structure, would be of great value. By such a process the manganese content could be stepped up to approximately 40 percent. The phosphorus content would, of course, step up in the same order.

### Manganocalcite or Carbonate Ore

This ore occurs as irregular runs in the upper portion of the Fernvale formations, in thicknesses of 1 to 2 feet. High-grade, hand-picked material will contain about 32 percent Mn, 7 percent  $\text{SiO}_2$ , 10 percent  $\text{CaO}$ , and 0.15 to 0.50 percent P. Some of this material is being shipped to Knoxville for use in an electrolytic manganese plant. It cannot be concentrated much higher than 35 percent Mn, since the manganese occurs mainly as a manganocalcite and not rhodochrosite. It is excellent raw material for electrolytic manganese, since it requires no roasting to be leachable. It is too high in phosphorus to be calcined and used as a ferromanganese ore.

### Black Rock

Disseminated manganese oxides in the upper Fernvale limestone and occur over wide areas to a thickness of 1 to 2 feet. Averages about 15 percent manganese, although hand-picked material may run up to 30 percent Mn. Ore contains considerable free calcite that can be eliminated by gravity concentration. High phosphorus prevents use as source of ferromanganese.

### Caddo Gap or Mena District, Ark.

Ore occurs as psilomelane and other oxides in a novaculite gangue. Float ore will carry 45 to 52 percent Mn, 2 to 10 percent Fe, and 0.15 to 0.45 percent P.

Milling-grade ore averages 20 percent Mn and 0.115 percent P, and this can be concentrated after crushing to 10-mesh by tables and flotation to 48 percent Mn, 5 percent Fe, 10 percent  $\text{SiO}_2$ , and 0.25 percent P. Region is being actively prospected at present time by several companies. Private estimate of ore reserves by Richards of Steelville, Mo., places reserves at approximately 200,000 tons. A centralized mill might well be placed in this district. From present information, production under favorable price conditions would not be large. A maximum production of 15,000 tons per year might be produced.

### Leadville, Colo.

Primary Ore. - Manganosiderite containing 14.2 percent Mn, 25.2 percent Fe, 4.6 percent  $\text{SiO}_2$ , 0.37 percent Pb, 0.6 percent Zn, 1.18 percent S, and 0.030 percent P. Most of the silica and the sulfides can be extracted by flotation. Material suitable for spiegel or for use as raw material for Bureau of Mines method of producing ferro by a smelting process.

Oxidized Ore. - Shipped for use in making spiegel; and will contain 18.6 percent Mn, 20.1 percent Fe, 15.9 percent insolubles, and 0.04 percent P. Since the ore is an oxidation product of manganosiderite, the manganese and iron oxides cannot be effectively separated by ore-dressing methods.

### Lodd District, Calif.

Oxide ore, some direct shipping, some low-grade that must be jigged. Samples not examined by Bureau of Mines.

1918 production from California 24,000 tons, which was shipped by some 47 operators.



## Cartersville District, Ga.

Ore occurs as nodules of psilomelane and other manganese oxides, with chert fragments and limonite particles in residual clay. Milling consists of log washing, jigging the coarse material and tabling the fines. Gravity concentrates contain 30 to 45 percent Mn and 5 to 17 percent Fe. Ore can be roasted and iron rejected magnetically. Phosphorus more closely associated with limonite than with manganese oxides resulting in a manganese and non-magnetic product of ferro grade.

(See Bureau of Mines Information Circular 6768, p. 50.)

### Typical serpentine

Size	Product	Wt.	Assay percent			
			Mn	Fe	Insol.	P
1"	Unroasted ore		32.8	17.9	7.4	0.170
	Mag. concts.	38.7%	12.4	45.5	12.0	.259
	Nonmag. prod.	61.3	51.7	2.3	5.0	.118
	Heads	100.0	36.5	19.0	7.8	.173

Size	Product	Percent of total			
		Mn	Fe	Insol.	P
1"	Unroasted ore	--	--	--	--
	Mag. concts.	13.2	92.6	60.7	58.1
	Nonmag. prod.	86.6	7.4	39.3	41.9
	Heads	100.0	100.0	100.0	100.0

A centralized mill would go far toward increasing production from the district. There are many small deposits, and one could be log-washed at the pit and concentrates trucked to a central mill for jigging and tabling. These concentrates could then be roasted and magnetically separated. It is believed that such a plant could produce 30,000 tons of ferro ore per year under emergency conditions.

## Butte District, Mont.

Oxidized Ores - Most of rich oxidized ores of this district were mined years ago and those ores that remain are low in grade and too badly locked to be concentrated to a high grade product.

Carbonate Ores.- Carbonate ores from the Emma and other mines offer best possibility of securing large quantity of ferromanganese ore in the country. Reserves are estimated at 7,000,000 tons, and efficiency of concentration and calcination processes has been demonstrated. A nodulized concentrate containing 60 percent Mn, which is low in iron, silica, and phosphorus can be produced. The output from this area is limited to the rate at which the material can be mined and to the capacity of the concentrates and nodulizing plant.

## Philipsburg, Mont.

Most of the manganese in this area is in the form of pyrolusite and is recovered from its ore by electromagnetic separators. The ore is usually sold for battery purposes. Such ore is produced at an annual rate of 6,000 to 8,000 tons. Concentration tests on oxides of the district not suitable for battery purposes show they can be concentrated up to about 45 percent Mn, 12 percent  $\text{SiO}_2$ , and 0.04 percent P. In an emergency, the district could produce considerably more ore than is required for battery purposes, and this could be used for metallurgical purposes. The establishment of a central mill equipped with jig, tables, and a flotation circuit would lower the cost of producing concentrates as compared to the method employed in producing battery-grade ore.

Philipsburg area produced 100,000 tons of metallurgical grade in 1918. Some of the ore was concentrated locally and some in mills at Butte. A potential large producer in an emergency.

## Nevada

### Las Vegas - Three Kids Mine

Does not respond to gravity or flotation methods.  
Can be leached.

## Nevada (Cont'd)

### Pioche

Manganiferous iron ore - concentrating properties not known.

### Volmy

Jig tests made on minus 3 - plus 10- Mesh ore can be jigged and ferro-grade concentrates produced.

### Battle Mountain

Ferro-grade concentrates can be made by floating a gravity concentration. Flotation carried on upon 200-mesh material. Recovery of manganese relatively low.

Numerous small deposits in Nevada whose concentrating properties are not well known.

Production 1918 - 19,800 tons.

## New Mexico

### Little Florida Mountains

Ore in past has been hand picked and jigged. Fine-size (minus 1/4 ") stockpiled (Manganese Valley mine). Ore shipped of following grade: Mn - 45.75 percent, SiO<sub>2</sub> - 2.50 percent, Fe - 2.0 percent, P - trace. Feed to mill assays, 22 percent Mn.

Stockpiled fines - Average 20 percent Mn. Such material can be treated by tabling and flotation of fines. Sintered material of ferro-grade.

Brecciated Ores - Have not been milled. Assay approximately 15 percent Mn, 2 percent Fe, 50 percent Insol., 0.01 percent P. These ores can be concentrated up to approx. 41 percent Mn, 2 percent Mn, 2 percent Fe, and 10 percent SiO<sub>2</sub>. (P low) by crushing to 1/2 -inch followed by jigging and tabling. (Note: Low metal content of ore due to BaO content of psilomelane).

Reserves according to Hewett are 1,000,000 tons.

This district of decided value as a possible source of manganese. Centralized mill desirable. Possible production of 60,000 per year.

### Silver City

Ore of ferruginous manganese type, grade shipped approximately 16 percent Mn, 33 percent Fe, 5.5 percent  $\text{SiO}_2$ , 0.01 percent P. Iron and manganese oxides intimately locked. Such ore when roasted and magnetically separated can be split into a high-manganese and a low-manganese portion. Nonmagnetic portions contain approximately 40 percent Mn, 7 percent Fe, 10 percent  $\text{SiO}_2$ , and 0.03 percent P. Amount of manganese in nonmagnetic product varies from 33 to 57 percent, depending on degree of grinding (8 to 100 mesh). Standard-grade ferromanganese probably can not be made from this ore, although a slightly lower manganese and a higher-iron-content product can be produced. (See table 25, Bureau of Mines Information Circular 6768).

### Kessee (Northeast) Johnson and Carter Counties

Small isolated deposits of oxides, chiefly psilomelane in Limonite and gangue minerals are also present. Clay can be eliminated by log-washing, but size of deposits does not warrant jigging plant. Central jigging plant deserves consideration. Grade of concentrates will vary from 35 to 45 percent Mn. P varies from 0.5 percent. Some of the ores can be roasted and iron separated, giving a ferro-grade product. (Report of Investigations 2936, p. 3, Bureau of Mines). P and  $\text{SiO}_2$  more closely associated with Fe than Mn. Production of 15,000 tons of ferro-grade concentrates per year possible if P up to 0.30 percent is acceptable.

### Embreeville

Ore similar in character to that in Johnson and Carter Counties, Tenn. Some production at present from plant of Embree Iron Co. at Embreeville, Tenn., where coarse sizes are being jigged. Concentration tests made on finer portion of ore (minus 3/16 inch), which have been stockpiled

show that the minus-3/16-inch and 1/16-inch portion is readily concentratable up to a grade of about 45 percent Mn, 6.5 percent Fe, and 8.0 percent SiO<sub>2</sub> by jigging. The minus-1/16-inch portion can be concentrated by agglomerate tabling, giving a product assaying 42 percent Mn, 11.7 percent Fe, and 7.2 percent SiO<sub>2</sub>. These fine concentrates can be mixed with coarse product and grade maintained. Many small manganese properties in this area would make a central mill desirable.

### Virginia

Ore is similar in characteristics to those found in Tennessee and Georgia. First concentration step is a log-washing operation, followed by jigging and tabling to reject gangue. Grade of concentrates produced from such a flow sheet yields concentrates of about following grade - 45 percent Mn, 6 percent Fe, 10 percent insol., and 0.25 percent P. As with the Tennessee and Georgia ores, some of these ores can be roasted and magnetically separated to give concentrates of ferro-grade except for the phosphorus which from some ores may reach 0.30 percent.

Essentially same concentrating problems exist in Crimora and in Woodstock area. Central jigging plant would be useful in Crimora area.

Cedar Creek mill built at Woodstock, Va., in 1929 is an example of type of mill necessary to concentrate these ores. (See Bureau of Mines Information Circular 6768, p. 93 flow sheet.) State of repair of this mill not known.

### Washington, Olympic Peninsula

Small amounts of high-grade ore as hausmannite have been found and probably will be found that are marketable without treatment. By far the greater portion of the ores occurs in the form of various manganese silicates, such as bementite and neotocite. No marked degree of concentration can be achieved with these ores.

Letter report to: Bureau of Mines

Submitted by: F. D. DeVaney

August 7, 1940









## VI. METALLURGICAL PROCESS



## CHAPTER VI. METALLURGICAL PROCESSES

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## VI. METALLURGICAL PROCESSES

### A. BLAST FURNACE

The modern blast furnace is a vertical cylindrical structure 90 to 100 feet in height, and varying in diameter up to about 25 feet; it is constructed of firebrick and externally reinforced by a steel casing. The interior is divided into three main parts. At the bottom is the hearth or crucible, some 10 to 12 feet in depth. The second section is called the bosh and is 9 to 13 feet high. Above the bosh is the stack, some 70 feet high, capped by the furnace top. In general, the stack flares outward toward the bottom like an inverted cone, except for the upper 10 feet and the first 5 feet immediately above the bosh, at which points the walls are vertical.

Near the bottom of the hearth is the tapping hole, through which the molten metal is drawn from the furnace. About 4 or 5 feet above the tapping hole is another opening, known as the cinder notch, through which the slag is removed.

Located symmetrically around the upper circumference of the hearth just below the bosh are 10 to 16 openings, known as the tuyeres, which permit introduction of the blast to the interior of the furnace. Each tuyere is connected in turn to a large pipe about 4 feet in diameter called the bustle pipe, which circles the furnace and distributes the hot blast through a series of pipes to the individual tuyeres. The bustle pipe is, in turn, fed by the hot blast main, which runs from the stoves.

At the top of the bosh is the mantle, which completely encircles the furnace. The mantle is made of steel angles and plates and is supported by steel columns extending directly downward to the foundation of the furnace. The mantle provides support for the stack of the furnace, and its use allows removal of the entire bosh and hearth for rebuilding without disturbing the entire furnace.

The stack of the furnace is variable in construction and may be thin-or thick-walled. The thin-walled furnace is 9 to 18 inches in wall thickness and requires a water-cooling system to carry off the excess heat generated in the stack. In the thin-walled furnace, some additional support framework is needed to carry the weight of the top of the furnace. The thick-walled furnace may have stack walls up to 5 feet in which are usually not water-cooled above the bosh. With the furnace, the weight of the top is carried directly on the wall additional supporting structure.

The top of the furnace is equipped with a double bell and hopper. This arrangement permits charging the furnace without appreciable loss of furnace gas, since it forms a double gas lock. Various types of mechanisms are used to insure even distribution of the charged material at the top of the furnace. These are generally associated with the bell-and-hopper mechanism and the hoisting apparatus used to lift the charge to the furnace top.

Four openings are provided at the top of the furnace to provide for exhaust of furnace gases. These openings are known as offtakes and lead to a common pipe (called a downcomer or downtake), which carries the furnace gases to the area of the stoves where it is used to heat the hot blast that enters the furnace at the tuyeres.

To supply the hot blast for operating the furnace four stoves, which are almost the same size as the furnace itself, are generally used. Fundamentally the stoves are brickwork heat exchangers and burn furnace gas along with some other gaseous fuel to heat air to form the hot blast. The air that forms the blast is moved under pressure by pumping engines.

Before burning, the exhaust furnace gases are cleaned of dust particles being carried from the furnace. This cleaning is done by wet and dry cleaners and Cottrell precipitators. The dust recovered is known as flue dust; it often contains valuable amounts of metal and is treated and recharged into the furnace for further recovery.

### 1. Blast Furnace as a Producer of Manganese Ferro-Alloys

Reduction of manganese ores in the blast furnace varies somewhat as to the product. It has long been common knowledge that the blast furnace, although primarily designed to smelt iron ore, can be used to smelt other ores or combinations thereof. Such is the case of manganese-bearing ores. End products containing from 1 percent or less to 80 percent manganese are produced in blast furnaces all over the country, although only a relatively small number of these furnaces are actually considered to be primarily engaged in manganese smelting.

### Manganiferous Pig Iron

Present steelmaking practice holds that between 1.75 and 2 percent of manganese is desirable in pig iron smelted for open hearth furnace use. Iron ore mined in the Great Lakes Region averaged 0.77 percent Mn from 1940-49 for all grades on a dry basis. If it is assumed

that the iron ore contains 57 percent Fe dry and 0.77 percent Mn dry and that a recovery of all the metal occurs, then the end product would contain about 1.25 percent Mn. However, the recovery of the manganese is not as high as the recovery of the iron, or is the recovery of either complete under practical conditions. About one-third or less of the manganese passes out of the furnace in the slag, reducing the manganese recovered in the metal from the ore to about .82 percent. The balance of the manganese needed to produce a pig of 1.75 to 2.0 percent manganese must obviously come from other sources. An important source is the open-hearth slag which is recharged and resmelted. This slag may run as high as 8 percent Mn, and although the main purpose of recharging the slag into the blast furnace is to recover the iron contained, a large part of the manganese is also reduced and is recovered in the pig iron. Occasionally, scrap steel or iron is charged into the furnace, which may carry about 0.35 to 0.40 percent Mn. These items in the blast-furnace burden may be considered normal from the standpoint of pig-iron production; but, if the manganese in this normal charge is not sufficient to achieve the desired manganese content in the pig iron, the operator may resort to what is known as "sweetening." This sweetening consists of charging a relatively high-manganese-bearing ore along with the rest of the burden. In 1949, 1,045,527 tons of manganese-bearing material was used for this purpose. Of this total tonnage, just under 90 percent came from domestic sources and a little over 10 percent from foreign origin. Of the total manganese-bearing material added to blast furnaces in 1949, 89.5 percent contained 5 percent to 10 percent manganese, 6.7 percent contained 10 to 35 percent manganese, and 3.8 percent contained over 35 percent manganese.

It may be noted that virtually all of the 35 percent or better ore used came from foreign sources and therefore its use as a blast-furnace sweetener contributes to the import burden of the economy.

As yet the possible and practical limits to the ability of lower-grade domestic ores to substitute for high-grade foreign ores as part of the blast-furnace charge have not been determined. Statistics intimate that considerable substitution is possible during times of shortage. Factors for consideration in this respect are the quantity of gangue added to the furnace with the ores, the relative amounts of iron available in the "sweetening" ores, and the availability of the ores at the various plant locations.

Recovery of manganese in a furnace making pig iron is low compared to recovery in a furnace engaged in ferro-manganese production because the primary function of the pig-iron furnace is reduction of iron. As a result, the furnace is not run so as to recover the manganese

pig iron, and much of it eventually ends up in the slag and is  
led on the dump. However, the manganese in pig-iron blast-  
slag probably averages less than 1 percent, which, under present  
ogy is practically and economically unrecoverable.

Some segments of the steel industry have indicated that the re-  
manganese in the pig iron may be of secondary importance to  
er steel-making uses of manganese in the form of spiegeleisen  
romanganese by showing a tendency to cut back on the use of  
mining ores in the blast furnace when manganese is in short supply.  
It should be noted, however, that the manganese in pig iron is largely  
up by the open-hearth slags and, as such, constitutes the basis  
for work now being done on the recovery of manganese from these  
open-hearth slags. If no manganese was charged at the blast  
furnace and carried over to the open hearth in the pig, the amounts of  
manganese in open-hearth slag probably would not be enough to warrant  
the expense for the success of any of the reclaim processes being presently  
used. It should not necessarily be construed that a reduction in the  
manganese in the pig-iron furnace would result in an over-all  
loss of manganese. This question must go unanswered since, as far  
as is known, enough research has not been done to determine the effect  
of manganese in pig iron on the residual manganese in the steel and  
the general condition of the steel in the open hearth before manganese  
is added.

#### Spiegeleisen

The blast furnace producing spiegeleisen is similar to that pro-  
ducing ferromanganese. The basic difference is that, owing to the  
usually high amounts of silica and other gangue in spiegel-type ores,  
slag increases in volume and decreases in basicity. Both these  
factors tend to reduce the recovery of manganese. The increase in  
slag volume also substantially increases the quantity of coke needed to  
produce 1 ton of manganese as spiegel compared to that needed to pro-  
duce 1 ton of manganese as ferromanganese.

The most valid reason that can be given for production of spiegel-  
is that it makes possible use of manganiferous iron ores and  
low-manganese raw materials.

Several companies produce spiegel from time to time, including  
the U.S. Steel Coal, Iron & Railroad Co., Carnegie-Illinois Steel Corp.,  
the U.S. Steel Co., and the New Jersey Zinc Co. It may safely be  
stated that any plant engaged in the blast-furnace production of



ferromanganese can produce spiegel almost at a moment's notice, since the equipment and process are so similar.

The most consistent of the above producers of spiegel is the New Jersey Zinc Co., since it already has on hand a manganiferous zinc residuum that can be converted into a cash-producing material without the overhead of transportation to the plant site. The residuum runs about 12 percent manganese and 40 percent iron. However, the quantity of material produced in any given length of time is controlled by the zinc output of that period. Considerable tonnages of a lower-grade residuum running about 7 percent manganese are used in plants producing pig iron, both as a manganiferous sweetener and for its iron content.

Virtually all spiegeleisen produced in the United States is derived from domestic material; and only very small amounts of the alloy are imported, generally from Canada, so that this alloy is one in which the United States may be considered self-sufficient.

The use of spiegeleisen by the steel industry, as compared to other manganese alloys, has dropped rather sharply in recent years. This reduction in the use of spiegel has been due not to an over-all reduction in the use of manganese but in a shift from the use of low-manganese to high-manganese alloys, such as ferromanganese and silico-manganese. Unfortunately, manufacture of the higher-grade alloys requires the use of the higher grades of ores which are in short supply.

### Ferromanganese

Perhaps the most important point in which there is a difference in the production of spiegeleisen and ferromanganese in a blast furnace is in coke consumption. The smelting of spiegeleisen is closely aligned to the smelting of iron ore. In fact, large amounts of iron are smelted during the process, since the end product may contain in the range of 55 to 85 percent iron. It is not surprising, under these circumstances, that the consumption of coke per ton of alloy in spiegeleisen practice should more nearly approach pig-iron practice rather than ferromanganese practice. If the calculations and data gathered by the Bureau of Mines in 1919 are used, it is found that the ratio of pounds of coke per pound of alloy is

<u>Ferromanganese</u>			<u>Spiegeleisen</u>	
Coke, in pounds	6,320	== 2.82	3,950	== 1.76
Alloy, in pounds	2,240		2,240	

Table VI - 1. RECOVERY OF MANGANESE FOR SEVERAL DOMESTIC COMPANIES  
PRODUCING FERROMANGANESE, 1942-49.

	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
Company A	Percent Mn in ferro	79.02	79.07	78.73	79.35	78.55	79.30	79.80	78.90		
	Percent Mn in ore	47.86	49.74	50.86	50.78	48.38	48.92	47.18	46.03		
	Percent recovery	92.24	92.17	87.80	90.63	90.57	83.64	87.23	89.50		
Company B	Percent Mn in ferro	78.61	77.96	77.43	78.20	77.77	77.09	76.2	76.29		
	Percent Mn in ore	44.35	45.46	44.96	44.38	46.35	48.48	45.36	44.89		
	Percent recovery	85.80	83.77	86.01	86.22	85.02	80.87	84.27	83.40		
Company C	Percent Mn in ferro	79.50	79.00	79.00	79.25	79.10	78.50	78.50	78.50		
	Percent Mn in ore	43.18	46.70	45.51	41.21	42.27	39.54	40.29	40.74		
	Percent recovery	82.52	82.59	78.88	80.99	84.88	83.98	77.81	80.20		
Company D	Percent Mn in ferro	80.00	80.00	80.00	79.00	79.41	79.87	79.00	79.27		
	Percent Mn in ore	46.61	48.51	49.09	46.67	48.34	46.58	46.49	46.97		
	Percent recovery	85.87	85.70	85.49	85.28	81.47	90.83	82.50	87.30		
Company E	Percent Mn in ferro	83.56	82.26	81.07	81.36	80.79	81.36	81.00	81.00		
	Percent Mn in ore	47.62	49.30	49.51	49.14	49.23	51.17	53.16	50.11		
	Percent recovery	80.65	77.35	82.37	81.10	81.61	79.69	75.06	68.40		
Company F	Percent Mn in ferro							80.37	80.35		
	Percent Mn in ore							58.98	58.71		
	Percent recovery							92.07	90.80		

However, if the manganese contained in the alloy is considered on the basis of 74.9 percent Mn in the ferromanganese and 17.48 percent Mn in the spiegeleisen, the ratios take on a different appearance.

<u>Ferromanganese</u>		<u>Spiegeleisen</u>	
Pounds of coke	6,320	3,950	
	$\frac{\quad}{\quad} = 3.77$		$\frac{\quad}{\quad} = 10.09$
Pounds of Mn	1,677.8	391.6	

It may be assumed that both practices have improved since 1919. However, the ratio still seems to be valid today. Incomplete figures as submitted to the Federal Bureau of Mines by producers in 1948 show

<u>Ferromanganese (approx. 80% Mn)</u>		<u>Spiegeleisen (approx. 20% Mn)</u>	
Pounds of coke	4,450	2,800	
	$\frac{\quad}{\quad} = 2.23$		$\frac{\quad}{\quad} = 1.40$
Pounds of alloy	2,000	2,000	
Pounds of coke	4,450	2,800	
	$\frac{\quad}{\quad} = 2.78$		$\frac{\quad}{\quad} = 7.00$
Pounds of Mn	1,600	400	

Comparison of 1919 and 1948 data shows very little change in the comparative ratio.

<u>1919 data</u>	<u>1948 data</u>
10.09	7.00
$\frac{\quad}{\quad} = 2.68$	$\frac{\quad}{\quad} = 2.52$
3.77	2.78

This would indicate an improvement of only 6 percent in the comparative position of the two alloys insofar as coke consumption is concerned, which can be discounted for practical purposes, particularly in view of the incompleteness of the basic data.

History of United States Production. - Ferromanganese production in the United States was given a great boost during World War I, when the price became so attractive that producers entered the field with no competitive difficulties. Shortly after the end of the war the price fell

sharply as foreign producers again entered the domestic market. The general depression of the steel industry which began in 1919 depressed the price still further by slacking off the demand for the product. Domestic ore producers closed down during this period, and it was not until a tariff was made effective in September 1922 that any relief was in sight.

Great Britain Germany, Norway, and Canada supplied a large part of our demands at this time, and domestic production of ferromanganese dropped, until at one time only E. J. Lavino & Co. was actively smelting.

The middle 1920's witnessed several changes in the manganese picture. Domestic interests began to acquire holdings and interests in foreign manganese sources, the British began to suffer an industrial depression, domestic firms began to produce ferromanganese in quantities large enough to supply the smaller consumer, and the entrance of Russian manganese ore on the world market forced down the price of ore.

As a combination of these factors, imported ferromanganese was driven off the domestic market and was largely replaced by ferromanganese made in the United States from imported ores. At present comparatively little ferromanganese is imported, and that which does enter the country is generally of some special electric furnace grade and does not affect domestic blast-furnace production materially. During World War II the small amounts of imported ferromanganese virtually stopped, to be resumed only after cessation of hostilities.

## 2. Relative Importance of Blast-Furnace Production

The consumption of manganese as a ferro-alloy in the United States is determined largely by the consumption of ferromanganese. In 1948 and 1949 respectively, 670,774 and 617,645 tons of ferromanganese were consumed, which, when evaluated in terms of ore equivalent by multiplying by an approximate factor of 2, represent roughly, 1,341,000 and 1,235,000 tons of ore. For the same years, the consumption of all uses of manganese ore was 1,538,398 and 1,360,042 tons. Therefore, in 1948, approximately 87 percent and in 1949, approximately 91 percent of the manganese ore consumed was in the form of ferromanganese. Of the total ferromanganese, approximately 80 percent was produced in the blast-furnace plants. Thus, of the total use of manganese ore, in the neighborhood of 70 to 73 percent is consumed in the blast furnace for ferromanganese production. It follows that a 1-percent

change in this phase will result in an 0.7-percent change in the over-all manganese picture. Assuming a consumption of 1-1/2 million tons of manganese ore in a year, a 10 percent saving in blast-furnace manganese recovery would result in an over-all saving of 7 percent, which is just a little under our entire domestic production of manganese ore in 1949. Undoubtedly, the most obvious place to make a saving in the consumption of manganese ore is at the blast furnace.

### 3. Blast-Furnace Operation

The blast furnace is limited in the adjustments that can be made to vary its operation when on ferromanganese from its operation when used in producing pig iron. Most variations are brought about through changes in the burden or charge by varying coke:ore and limestone:ore ratios, or through changes in the amount and temperature of the wind blown. Probably the best single group of data that has been assembled and made public is the work of P. H. Royster of the Bureau of Mines, in Bureau of Mines Bulletin 173 (published 1919); and, although the figures may not be applicable today under improved furnace practice, the conclusions are still valid. This work has been used as a basis for much of the following information.

### 4. Effect of Coke:Ore Ratio

Royster illustrated that, when what he terms excess carbon is used, the amount of manganese in the slag is reduced. The actual charging of an excess amount of coke over that required to reduce the manganese at an average hearth temperature will increase the cost of operation of the furnace as well as the volume of slag owing to the additional coke ash unavoidably charged with the coke. The information indicates that there is a relationship that can be determined for any furnace and that this relationship can be used by the furnace operator to achieve a maximum recovery of manganese by balancing off the drop in the percentage of manganese in the slag against the increase in the volume of the slag.

### 5. Effect of Limestone:Ore Ratio

It has been demonstrated that, in the blast furnace, there is a definite relationship between the basicity of the slag and the percentage of any metal retained in the slag. The ratios

$$\frac{\text{percent CaO} + \text{MgO}}{\text{percent SiO}_2 + \text{Al}_2\text{O}_3} \quad \text{or} \quad \frac{\text{percent CaO} + \text{MgO}}{\text{percent SiO}_2}$$

are taken to indicate the basicity of slags. By the first formula, ratios less than 1 are "acid," while those greater than 1 are "basic". The oxides of manganese act as bases in the furnace and tend to be interchangeable with the lime in the slag. A high basic content or a highly basic slag will tend to reduce the percentage of manganese in the slag and increase the recovery. Therefore it may be claimed that basic slag is desirable in the reduction of manganese. It will be noted that the added limestone represents a greater volume of slag, so that the relationship between the percentage of manganese lost to the slag and the slag volume again becomes valid.

The more basic a slag is run, the more viscous it is at any one temperature, so that a highly basic slag may require a hotter hearth temperature to maintain the proper fluidity.

#### 6. Effect of Temperature and Rate of Driving

Raising the blast temperature has, in part, the same effect as an excess of carbon because it increases the temperature of the furnace hearth, with the advantage of not introducing any more slag volume. The effectiveness of increasing the hearth temperature is indicated by the table below admittedly an assembly of guesses due to lack of exact experimental data. (1)

Hearth temperature, °F.	Si expected	S expected	Mn expected, 1% ore	C expected
2,500	0.80	0.050	1.10	4.25
2,550	.95	.040	1.20	4.27
2,600	1.05	.030	1.30	4.30
2,650	1.15	.027	1.40	4.35
2,700	1.30	.024	1.50	4.40
2,750	1.50	.022	1.60	4.45

Royster measured the rate of driving by the pounds of gross slag reduced per minute per square foot of hearth area. The validity of this is shown by the fact that manganese is finally reduced in the hearth. Therefore, the longer the molten material remains in the hearth area, the greater the quantity of manganese that will be reduced. A slower rate of driving will permit a longer time for the metal to remain in the hearth, so that slower driving should tend to a higher recovery.

### Summation

The amount of manganese lost in the slag is decreased by (a) Raising blast temperature; (b) increasing basicity of the slag; (c) Charging more coke; and increased by (a) fast driving; (b) increased slag volume.

All these factors cannot be controlled simultaneously in a direction that will obtain better manganese recovery, but the furnace operator can achieve a balance among them. Probably the most important factors are the basicity of the slag, the volume of the slag, and the hearth temperature.

The factors discussed thus far are those concerned directly with furnace operation. However, it is apparent that the quality of the materials provided to the furnace operator will largely limit his ability to make the proper adjustments. Consideration should be given to the three major components of the blast-furnace charge, the ore, the coke and the limestone,

## 7. Components of Blast-Furnace Charge

### Ore

Primarily, the ideal ore should contain as high a percentage of manganese as possible, with a minimum of silica plus alumina ( $\text{SiO}_2 + \text{Al}_2\text{C}_3$ ) and enough lime and magnesia to create a basic slag. Other elements, such as phosphorus, copper, lead, zinc, etc., should be absent or held to a very low limit. Iron should be about one-sixth to one-eighth of the manganese.

Any reduction of the silica-plus-alumina factor will be of value, due to a corresponding reduction which, it has been shown, will increase the over-all recovery of manganese.

Obviously, since most of the ore used in the manufacture of ferromanganese is imported, the producer to some extent lacks control over the quality, except for the influence of premium prices for better grades. Even the willingness to pay more for a better grade is limited in that, if the grade is not available on the world market, it cannot be purchased at any price.

Even though some producers are willing to pay a premium for the best grades available, the national situation is not greatly improved because it will mean that some other producer probably will have

lower grade. This is true at present because the United States consumes about 40 percent of the world's production and is buying just about 100 percent of that part of the annual world production that is available.

Fortunately, both coke and limestone are domestic products and as such are more easily subject to quality control.

### Coke

Unfortunately, the composition of coke is not publicly known in the ferromanganese operation. However, certain estimates can be made on the bases of general knowledge. It is common practice, in making coke, to try to produce a standard commodity; to do so, different coals are blended in so far as possible. A glance at typical analyses of the coals of the United States, particularly in the coke-producing areas, will show that an average analysis, as given below, will not vary appreciably from the true average.

#### COKE ANALYSIS - 1948 - ESTIMATED, IN PERCENT

Moisture -----	3.50		
Ash -----	11.06		
Volatile -----	1.15		
Fixed carbon-----	84.29		
S -----	1.20	Fe <sub>2</sub> O <sub>3</sub> -----	1.33
SiO <sub>2</sub> -----	6.79	CaO -----	.61
Al <sub>2</sub> O <sub>3</sub> -----	2.15	MgO -----	.18

An analysis of the ore mix may be found in a somewhat similar fashion as the analysis for coke. The best available estimate of spot analysis is as follows,

#### ORE MIX SMELTED - 1948 - ESTIMATED, IN PERCENT

Mn -----	46.65	BaO -----	.20
Fe -----	6.29	Na <sub>2</sub> O -----	.23
P-----	.112	K <sub>2</sub> O -----	.18
SiO <sub>2</sub> -----	5.61	CO <sub>2</sub> -----	1.22
Al <sub>2</sub> O <sub>3</sub> -----	2.65	Conct. H <sub>2</sub> O ----	2.85
CaO -----	1.29	Moisture -----	2.85
MgO -----	.53		



P. H. Royster made available the following information in a letter to C. C. Ralston on November 7, 1950:

According to the 1948 Yearbook, manganese recovery was 84.60 percent and the manganese content of the alloy produced was 78.42 percent. This fixes the ore charged at 3,980 lb. per N. T. of alloy. Accompanying the manganese in the ore, there is 224 lb. of  $\text{SiO}_2$  and 105 lb. of  $\text{Al}_2\text{O}_3$  - a total acid gangue of 329 lb. A furnace operating with a coke consumption of 4,150 lb. per N. T. of alloy will introduce into the furnace 274 lb. of  $\text{SiO}_2$  and 93 lb. of  $\text{Al}_2\text{O}_3$  - 367 lb. of acid oxides. It is seen thus that the acids from the coke ash outweigh the acid gangue from the ore.

As has been shown already the acid gangue is the determining factor in slag volume, since the more acid gangue present, the more limestone must be added. On the basis of the coke and ore actually used in 1948 and an estimated flux figure of 1,365 pounds of limestone per N. T. of alloy, the slag volume will run 1,700 pounds. If 8 percent manganese in the slag is assumed, Mn in the slag would run 136 pounds, or 7.3 percent of the Mn in the ore charged.

Since the percentage of manganese in the slag is primarily a function of hearth temperature and basicity of the slag, a reduction in volume of slag would result in a reduction in the amount of manganese lost and an increase in the over-all recovery.

#### Limestone

A similar case may be presented for limestone, since an average analysis will demonstrate the presence of acid oxides here as well as in coke and ore.

#### Limestone analysis - 1948 - estimate, in percent

$\text{SiO}_2$	1.12
$\text{Al}_2\text{O}_3$	.41
$\text{CaO}$	44.88
$\text{MgO}$	7.50
$\text{Fe}_2\text{O}_3$	.63
$\text{CO}_2$	43.36
Moisture	2.10

Since no accurate or complete slag analyses are available on ferromanganese blast-furnace slags, no accurate figure can be given

as to the percentage or the actual quantity of manganese lost through this medium. However, it should be pointed out that, even if all the figures used above were completely unsupported, the basic metallurgy that the data demonstrate is valid, as any blast-furnace operator knows.

Two pathways then lie open in the future. The present loss of manganese in the slag may be judged to be acceptable in the light of the difficulties that may attend the supplying of low-ash coke and a good grade of limestone and any action on improving coke and limestone deferred until use of lower-grade ore is obligatory; at that time, the necessary changes can be made to offset, in whole or in part, the increased slag volume, or the situation may be deemed so acute as to make whatever improvement that could be accomplished through better coke and limestone as soon as possible.

Regardless of when such action would be taken, it should be noted that, by improving the analysis of the coke to the ferromanganese furnace, there probably would be a reduction in the grade of coke to other coke-consuming industries, of which pig-iron blast furnaces form the larger part. A reduction of grade of coke to pig-iron furnaces probably would decrease the rate of production somewhat, so that the gain on the manganese side would have to be equated against the loss on the pig-iron side.

#### 8. Possibility of Conserving Manganese by Recovering Gas-Line Losses in Blast Furnaces

The recovery of manganese from ore in manufacturing ferromanganese in 1949 was 83.3 percent, a figure that includes both blast-furnace and electric-furnace production. Since such a large proportion of the total ferromanganese tonnage is produced in blast furnaces, it seems to be a valid assumption that blast-furnace recovery may be estimated at approximately 82 percent, giving a process loss of 18 percent.

Although ferromanganese furnace slags are seldom analyzed, so that no absolute data are available, empirical observation indicates that about half of the 18 percent loss of manganese is in the slag. The only remaining point at which material may be lost is the furnace stack, which must be assumed responsible for the other half of the loss. Gas-analysis data again are lacking, so that trustworthy information as to the amount of manganese carried out of the furnace in the stack is not available.

Since empirical data indicate that the stack loss runs in the neighborhood of 9 percent and comparison with similar blast furnaces producing pig iron demonstrates that gas-line losses of iron are large enough to warrant collection, it seems obvious that collection of gas-line loss of manganese should receive the same attention, particularly in view of the large price differential between manganese ore and iron ore.

A special committee representing virtually all the major consumers of manganese in the steel industry and ferromanganese industry submitted a report in June 1949 to the National Security Resources Board regarding the conservation of manganese. One of the recommendations of the committee was "the development of processes to recover manganese from open-hearth slags and other waste products containing manganese." Further remarks in the report point up the importance of open-hearth slag as a possible waste-product source of manganese, but no mention is made of recovery of the manganese lost in the blast-furnace stack.

A differentiation must be made between gas-line dirt caused by mechanical means and that caused by volatilization. Material lost from the stack due to dusting of the furnace charge by the force of the blast, slips, charging, etc., has been recognized for a long time as being recoverable. Such dust is caught in dry-dust catchers, washers, and the like, returned to the furnace after being briquetted or sintered, and recirculated; it does not materially affect furnace efficiency. The loss that occurs as fume is due to volatilization in or near the hearth area, and the particles are so small as to not be amenable to collection by mechanical means. The most commonly used means of collecting these fume particles is some form of precipitator.

In this connection, E. T. Warren of Tata, Inc., of New York recently reported to the Bureau of Mines regarding operation of a blast furnace in India. The furnace is operated part of the time on pig iron and is occasionally used for ferromanganese production. The gas line of the furnace is fitted with dust-catching equipment and a precipitator. Although the precipitator was installed for use in the production of pig iron, it is an integral part of the system and therefore continues in operation while the furnace is producing ferromanganese. According to Warren, no difficulties are experienced in the change-over, and no adjustment in operational procedure is necessary to collect the manganese-bearing fume.

Since volatilization is due to the heat of the furnace in the combustion zone and the hearth, it follows that certain chemical changes

y be expected in the fume which make it differ from the charge of furnace, whereas this does not apply to the dust separated mechanically by the force of the blast. If it is assumed that volatilization of materials at the hearth is fairly equal, with the exception of the carbon, the manganese in the fume should run in the range of 20 percent, dependent on individual furnace operation. One reason advanced for collecting the fume is that it would contain too many products other than manganese in such large amounts that it would make end recovery of manganese economically impractical.

From a metallurgical standpoint, two of the most difficult materials likely to be present in the fume would be alkalies and cyanides. It is immediately suggested that, since the capital cost of the precipitating equipment plus the low operating expense are virtually the only cost items that need be charged against the delivery of approximately 8 percent of the total volume of the manganese delivered and paid for as ore, the cost of the precipitated material would be just about nothing. Whatever differential would exist between the cost of raw ore and the precipitated ore could then be applied to the use of some method of removing that portion of the precipitated fume that would be injurious and thus provide synthetic rechargeable ore at a cost equal to or perhaps lower than the cost of the original ore. An additional advantage would obtain from the fact that a cleaner gas would be available for burning at the blast-furnace stoves, lengthening the period of operation between shut-downs for cleaning.

In view of the present threat of development of emergency conditions as to the supply of manganese and the possibilities that treatment of blast-furnace fume may increase ferromanganese production (substantiated in part by the information available from pig-iron production), it would seem that a program of research and practical investigation was merited and should prove advantageous.

## B. ELECTRIC-FURNACE PRODUCTION OF MANGANESE FERRO-ALLOYS

Use of the electric furnace for manufacturing manganese-bearing ferro-alloys was begun as an industry at the outbreak of World War I. Several European companies and two United States firms intermittently produced electric-furnace ferromanganese during periods when the high price of ferromanganese made the process economically possible. The real birth of the electric smelting of manganese ores was in 1916 when two factors - the high price of ferromanganese and the necessity of using domestic ores to supply the requirements of the steel industry -

prevailed simultaneously. Although many of the plants producing ferromanganese electrically went out of production after World War I owing to the drop in price, the industry has survived. This survival has been due to gradual submersion of the price factor and the corresponding emergence of a technological factor. The increased technological knowledge of the metallurgy of steel has demanded the use of more and better ferroalloys; this demand, in turn, has been answered by the development of medium- and low-carbon ferromanganese and silicomanganese. The demand for special steels during World War II gave great impetus to usage of these special alloys, and the succeeding years have seen a continuing and increasing demand. Although the blast furnace is by far the largest producer of standard ferromanganese, it cannot produce the medium- and low-carbon grades or silicomanganese. By its ability to produce these special grades of alloy, the electric furnace has earned itself an important position in the ferro-alloy field.

At this point, it is well to note that the electric furnace is used extensively in the production of many other ferro-alloys, including ferrovanadium, ferrotungsten, ferrotitanium, ferrochromium, and ferromolybdenum. Many of these electric furnaces may be adapted to the production of ferromanganese with little or no trouble; however, the increased production of one alloy at the expense of another does not seem to be particularly advantageous on the surface. It may be assumed that the normal functioning of supply and demand for the products of these furnaces eventually dictates the percentage division because of the furnaces as to what type of alloy may be produced. The dictates of an emergency situation may well override these natural economic factors and demand that the furnaces shift from their normal product in favor of one or the other of the more critical alloys. Furthermore, the matter of transportation, the elimination or addition of facilities, or the availability of electric power may call for shifts in product between furnaces.

### 1. Ratio Conversion Factors

Changing furnaces over from one product to another is limited by other factors that must be considered. Auxiliary plant facilities from the standpoint of physical ability to handle either the volume or type of the new product and the raw materials may be smaller than needed and necessitate so much revamping and attendant delay in over-all production that establishment of a new facility may be quicker and more economical in the long run. Second, it must be realized that the furnace can be no better than its operating crew. Operators well-trained in the manufacture of certain products may be completely ignorant of the

Table VI - 2. COMPARISON OF RESULTS WITH  
BLAST FURNACE AND ELECTRIC FURNACE (2)

	Blast furnace	Electric furnace
Ore ----- pounds per pound of metal	2.675	2.921
Coke ----- pounds per pound of metal	2.824	---
Coal-----pounds per pound of metal	.089	1.267
Limestone -pounds per pound of metal	1.049	.475
Lime ----- pounds per pound of metal		.113
Ore analysis, percent:		
Mn -----	40.33	34.8
SiO <sub>2</sub> -----	8.60	13.2
Slag ----- pounds per pound of metal	1.427	1.263
Metal, percent:		
Mn -----	74.9	73.6
Si -----	1.15	2.9
Slag analysis, percent:-----		
CaO and MgO-----	41.75	40.2
Al <sub>2</sub> O <sub>3</sub> -----	14.0	7.9
SiO <sub>2</sub> -----	28.1	28.6
Mn -----	10.6	12.4
Carbon---- pounds per pound of metal	2.376	.568
Mn:		
Charged pounds ---- percent	2382.0	2291.0
To metal ----- percent	72.0	72.0
To slag ----- percent	14.7	15.0
Stack loss----- percent	12.8	13.0

methods used in making some new product.

To avoid sudden shortages of alloys, which could arise from sudden dislocation of the producing facilities, it would seem advisable to take three construction steps:

1. A comprehensive survey of alloy-producing facilities, both electric and blast furnace.
2. Stockpiling of finished products, insofar as possible, so as to have a backlog of supplies for consumers to tide over periods of dislocation.
3. Creation of an operating manual, setting forth the fundamentals of operation of the various types of furnaces for the production of the different alloys to serve as a starting point for the operator in adapting his operation to a new product.

As directly concerns the production of manganese ferro-alloys, there is not only a relationship to be found between electric furnaces, but one between electric furnaces and blast furnaces in the production of standard or high-carbon ferromanganese.

On the basis of information gathered by the Federal Bureau of Mines in 1918 on operation of blast furnaces and electric furnaces to produce ferromanganese, it may be assumed that an electric furnace apparently can use a somewhat lower-manganese and higher-silica ore with the same recovery as a blast furnace. Although operating techniques have been improved considerably on both types of furnace since 1918, it seems a fair assumption that the edge on recovery has been maintained by the electric furnace. Several elements tend to work in favor of electric smelting. Perhaps of primary importance is the smaller quantity of coke introduced into the furnace. Since all coke contains a certain amount of ash, about half of which is silica, and since silica exercises control over the volume of slag produced, the more silica, the more slag; thus, the blast furnace will always tend toward a higher volume of slag. Assuming the same percentage of manganese in the slag of the two types of furnace, the more slag, the more manganese lost, with a resultant decrease in recovery.

Certain experiments now being made by both the industry and the Bureau of Mines may result in a shift in this balance in favor of the blast furnace. Manganese may be lost in two places in a blast furnace, in the slag or in the dust up the stack. Theoretically, variations in the furnace operation, the balance of the loss can be thrown either way, so that, if a method of recovery can be evolved for either the slag loss or the stack loss, the action of the furnace may be pushed toward the loss that can be recovered.

The highest recovery of manganese, reported to the Bureau of Mines, on an average yearly basis, when smelting is done in an electric furnace, runs 91.8 percent. This recovery was reached with the use of an extremely high manganese ore and perhaps is not truly comparable; however, it may be seen that, with an over-all loss of 16.7 percent as indicated by the over-all recovery for blast and electric furnaces in 1949 in the Minerals Yearbook, if half the loss were recoverable, blast-furnace recovery would be 82 percent plus 9 percent or 91 percent. Thus, the efficiency, recoverywise, of the blast furnace would be slightly higher than the best figure for electric furnaces, even with a 20 percent lower manganese content in the ore. This becomes even more important when viewed in the light of the fact that it is indicated that the 10 percent additional recovery in moving from an 80 percent recovery to a 90 percent recovery in an electric furnace may only be accomplished by a 20 percent increase in power consumption when operating in the range of ores normally rich in manganese.

### C. ELECTROLYTIC MANGANESE

Electrolytic manganese is a relatively new product on the market, having first been made in appreciable quantity in 1939, when about 45,000 pounds was produced. Over 4-1/2 million pounds was produced in 1948. The only commercial producer of electrolytic manganese in the United States is the Electro Manganese Corp., at its plant at Knoxville, Tenn.

Thus far users of manganese have developed certain uses for the electrolytic product wherein the differential in price over that of other alloys can be justified by costs. In steel electrolytic manganese is used almost exclusively in stainless, tool, and special alloy steels. Approximately half of the electrolytic manganese goes into ferrous production and half into nonferrous, such as copper, nickel, aluminum, and magnesium alloys, and into chemicals.

#### ANALYSIS OF ELECTROLYTIC MANGANESE, PERCENT (2)

Mn	Fe	S	P	C
99.98 min.	0.001 max.	Not found	Not found	0.004



At present time the Knoxville plant is using high-grade imported ores. To obtain a steady, consistent process, these ores are mixed and blended. Experimentation with domestic low-grade ores has led to certain conclusions by the industry.

Unlike some other electrolytic processes, impurities in the catholyte do not deposit with resultant impairment of current efficiency, but some impurities inhibit manganese deposition in favor of hydrogen evolution. It would be poor judgment to base an electrolytic manganese plant on a certain mine, unless most exhaustive tests had first been made. It is not intended to give the impression that only a few particular ores can be treated. We can, with suitable flow-sheet changes, manage to use most ores, but it is expensive and unpleasant to make these changes.

If less rich ores were used by the Knoxville plant it is obvious that certain facilities would have to be expanded, such as roasting facilities, residue disposal, etc. Low grade ores that could possibly be upgraded to match imported ores would eliminate some of the immediate electrolytic production problems but would call for beneficiating equipment.

No plant operating on a single ore can, in all probability, be as economical as one so located as to draw on a variety of ores. The correct blending of ores is even more important than in the case of a non-ferrous smelting operation or an electrolytic zinc plant. In the electrolytic zinc process the experience as to the nature of the plant feed has been parallel to manganese, that is, the higher the grade (of ore) the better. (4)

These statements indicate that, although it is not impossible to expand the range of the types of raw material that can be processed through electrolysis, considerable investigation and experimentation will be required.

Electro Manganese officials seem to feel that the industry will be able to keep up with the demand for the metal, particularly if the grade and quality of the ore do not change too radically.

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## VII. UNITED STATES DEPOSITS



## CHAPTER VII. UNITED STATES DEPOSITS

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## VII. UNITED STATES DEPOSITS

### A. ARTILLERY MOUNTAINS, MOJAVE COUNTY, ARIZ.

According to Lasky and Webber, (1) hundreds of millions of tons of low-grade manganiferous sediments have been proved in a 25-square-mile area on the west side of Bill Williams River near Alamo, west-central Arizona, as the result of investigations over the past 20 years. Total tonnages amount to an assured minimum of 200,000,000 tons averaging 3 to 4 percent manganese, of which 20,000,000 tons contain 5 percent or more manganese and 2,000,000 to 3,000,000 tons over 10 percent manganese.

Although it is not expected that mining will be difficult, it will have to be by underground methods for most of the area, due to thick overburden. The Bureau of Mines is now conducting experimental mining operations on the east edge of Manganese Mesa, where the formation outcrops, to test new mining techniques. At present, only the enriched portions of the formation called hard ore, are being considered for mining because of metallurgical problems yet to be solved before the manganese content of the deposits as a whole can be recovered on a commercial scale. The physical nature of the material is such that simple gravity separation (2) does not appear usable. Research by M. A. Hanna Co. and the Federal Bureau of Mines, however, was expected to lead either to improvements in flotation or hydrometallurgical techniques (3) or to new treatment methods that will make these resources available, at least from a technical standpoint. The Federal Bureau of Mines has recovered metallic manganese from these materials on a laboratory scale. (4)

Three types of manganiferous deposits have been recognized in the area: (a) Stratified oxide deposits in the clay, sandstone, conglomerate, and other sediments of the Artillery, Chapin Wash, and sand trap formations; (b) deposits in openings in old fracture zones; and (c) enriched and replacement deposits in later fracture zones. Of these, only the stratified oxide deposits of the Chapin Wash formation offer commercial promise largely because of their immense tonnage.

Except for the portions (called hard ore) enriched by descending waters, the deposits of the Chapin Wash formation are unchanged from the form in which they were originally deposited. They are called syngenetic deposits and presumably were laid down as part of the formation that contains them as lake-bottom sediments. Amorphous or non-crystalline iron oxides are intimately associated with amorphous

anese oxides in these sediments, which contain barren layers in series as well as the mineralized.

Manganese content ranges from 1 percent or less to as much as 20 percent in the locally enriched areas, but more than 20 percent is by far the greatest portion contains less than 5 percent manganese. The average manganese content of the unaltered formation, largely manganese sandstone and conglomerate, is 3 to 4 percent; average content of enriched material is 6 to 7 percent. The average manganese material contains 3 percent iron, 0.08 percent phosphorus, 1.1 percent aluminum, and minute amounts of copper, lead, and zinc. The manganese content changes only gradually within individual beds but is known to change abruptly from one bed to another. Both iron and manganese are remarkably uniform as to content when large volumes of the material are considered.

The manganese beds of the Chapin Wash formation are found in two zones, separated some 750 to 1,000 feet stratigraphically. They underlie most of the valley between the Rawhide and Artillery Mountains in the southern part of Mojave County. The lower zone outcrops mainly along the Rawhide Mountains on the southwest side of the valley, where it can be traced along the strike for nearly 4 miles. Although as much as 50 feet thick, this lower zone, as far as may be seen from exposures, consists only of widely separated manganese lenses among thicker, more frequent barren members. It has not been explored at depth. The upper zone outcrops along the Artillery Mountains on the northeast side of the valley and is found at or near the top of the Chapin Wash formation. It is continuously traceable for 3 miles along the strike, and the zones as a whole may be followed for 6 miles, though discontinuously. This zone has been tested by diamond drilling and found to be continuously manganese for at least a mile down its dip. The thickness of the zone ranges from a few feet up to 400, and in places it is almost continuously manganese for thicknesses up to 165 feet, although the average aggregate thickness is 65 feet for the two main blocks of the deposits, the Maggie and the Lower Chapin, which cover about 1,000 acres.

In estimating tonnages, the Federal Geological Survey (5) used a factor of 16 cubic feet per ton for the main body of manganese sediments and 15 cubic feet per ton for the enriched or hard portions. The ton unit, however, is not stated, whether short, long, or metric. It was assumed that no bed less than 5 feet in thickness could be mined itself unless of exceptional richness and also that barren seams less than 5 feet thick lying between minable manganese layers would

Table VII - 1. RESERVES OF MANGANESE ORE IN THE ARTILLERY MOUNTAINS, ARIZONA,  
CLASSIFIED ACCORDING TO KIND OF ORE

(Estimates based on explorations to June 1941, in thousands of tons)

Kind of ore	Maggie block		Upper Chapin block		Lower Chapin block		Price block		Totals	
	Tons	Manga- nese (per- cent)	Tons	Manga- nese (per- cent)	Tons	Manga- nese (per- cent)	Tons	Manga- nese (per- cent)	Tons	Manga- nese (per- cent)
Hard ore	15,000	6.5	400	8	2,000	7	1,500	b/ 1.5	b/ 15,500	6.5
Sandstone ore	40,000	3.0	20,000	4					65,000	3.5
Clay ore	25,000	3.5	15,000	4					40,000	3.5-4
Total sampled	80,000	3.75	b/ 35,000	4	2,000	7	1,500	1.5	b/ 120,000	3.5-4
Unsampled	40,000	c/ 3.0	15,000	c/ 4					55,000	3-3.5
Grand total	120,000	3.5	50,000	4	2,000	7	1,500	1.5	b/ 175,000	3.5-4

a/ Basic data not as good as for Maggie block, but estimates given are thought to be of correct order of magnitude.

b/ Round numbers.

c/ Estimated.

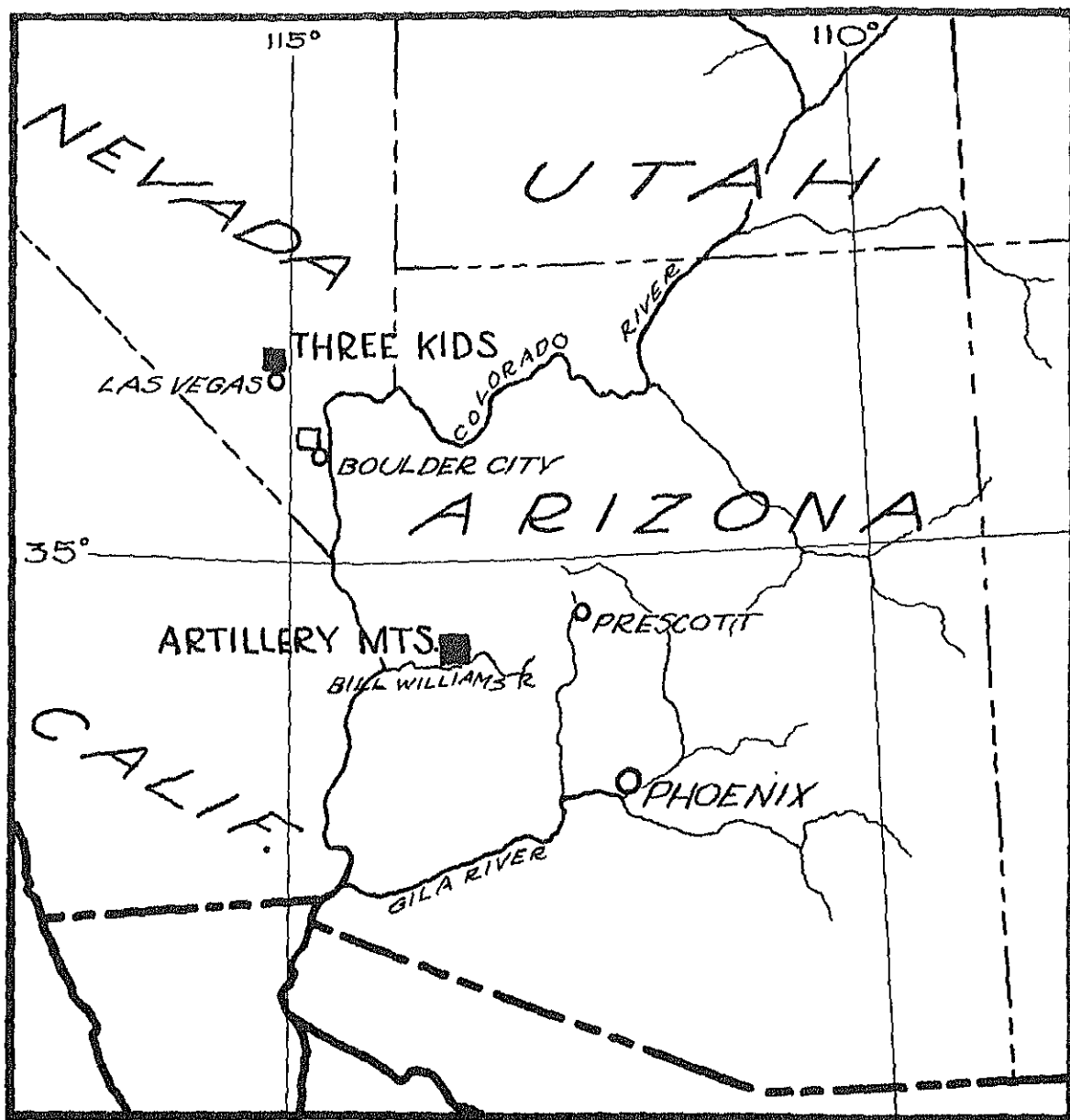


FIGURE VII-1. Manganese deposits in Southwestern U. S. A.

have to be taken in the mining process. A cut-off grade of 1.5 percent manganese was used generally in estimating minable tonnages, although some material as low as 1 percent is included. Details of the entire area are given by Lasky and Webber in the report cited. No estimate of reserves was made for the lower manganiferous zone.

#### B. BATESVILLE, ARK. (6)

The Batesville manganese district is in north-central Arkansas, near Batesville. It is an east-west belt, 4 to 8 miles wide and 24 miles long. Ore has been extracted from it since 1849; most of the production came during two periods of activity, one from 1885 to 1898, and the other beginning in 1915 and continuing to the present time. The greatest annual output was during World War I, when production amounted to 10,140 and 7,731 tons in 1917 and 1918, respectively. Before the First World War, the ore shipped consisted mostly of oxides; carbonate was picked out as well as possible by hand. Since the value of carbonate ore has become known, the production of both manganese ore and ferruginous manganese ore has included a considerable tonnage of carbonate with which are associated varying percentages of oxides.

The carbonate portion of the Batesville ores is made up of white, gray, pink, yellow brown, and reddish-brown varieties of manganiferous carbonates whose content of manganese ranges from a few percent to 38. The oxide minerals include psilomelane, hausmannite, braunite, manganite, pyrolusite, and wad. Small quantities of manganese silicates are also known.

The ore deposits are of three types: (a) Primary, or original, sedimentary; (b) replacement; and (c) secondary. Ores of type a were laid down with the sediments that enclose them. The deposits of type b are replacement bodies in limestone. The ultimate source of the manganese is thought to have been the minute quantities of manganese disseminated throughout the limestone itself. Deposits of type c present a variety of features but are, in the main, residual.

It is felt that manganese-bearing bodies of the types outlined are fairly numerous in the Batesville area and will be discovered and developed from time to time in future years "as conditions affecting the manganese industry of the region permit."

## 1. Reserves

The reserves of hard oxide lump ore are sufficient to maintain the present rate of production (5,000 to 6,000 tons per year) for many years. This material may be expected to contain 40 to 50 percent manganese, 5 percent silica, 5 to 6 percent iron, and about 0.2 percent phosphorus. However, ore bodies containing this reserve are small and isolated and must be sought and mined individually by small-scale underground methods. As a result, it is unlikely that production from deposits of lump ore could exceed 10,000 tons per year.

Reserves of low-grade wad ore containing an average of about 15 percent manganese, 7 to 37 percent  $\text{SiO}_2$ , 2 to 21 percent iron, and 0.1 to 1.2 percent phosphorus are sufficient to maintain an annual production of 25,000 tons per year for about 25 years. Phosphorus may be expected to average about 1 percent. The only recent production of wad ore was approximately 20,000 tons in 1942, and no method has yet been tried to recover the manganese from this material. Improvement of flotation techniques may well make such material available.

### C. AROOSTOOK COUNTY, MAINE

Although known for over 100 years, the manganese-iron deposits of Aroostook County, northeastern Maine, were first looked at seriously as a potential resource of manganese in 1941 when detailed exploration was undertaken by the State. This program was continued in 1942 by the Manganese Ore Co. Results of this work have been reported by White (7) and by Miller. (8)

To the end of 1944, on the basis of field work done and information then available, Miller estimated the known deposits to contain assured reserves of 1,300,000 short tons of manganese metal plus an additional 800,000 tons of probable metal. At that time the known deposits were grouped in three distinct districts. The northern district, to the west of the towns of Caribou and Presque Isle, contained some 20 deposits, of which the Dudley had the largest amount of higher-grade material. In the central district, some 25 miles south of Presque Isle, the Maple Mountain and Hovey Mountain deposits gave appearances of being large after only superficial prospecting. Littleton Ridge was conspicuous in the southern district, which centered around Houlton.

Recent exploration in the central area has vastly increased the reserve estimates given above, and the manganese-bearing area is now considered to extend more or less continuously for about 60 miles from

south of Houlton to somewhat north of Presque Isle as shown on the map which follows.

The average content of the manganiferous material, as given by Miller, (9) is about 9 percent with associated iron content about twice this amount. The manganese, however, in the primary or unoxidized deposits and in some of the oxidized areas is stated to be largely in complex oxide-silicate minerals; and to date, it is understood, no satisfactory commercial treatment process has been worked out for recovering manganese so intimately combined with other elements. The term "reserve", then, in respect to the Maine deposits, cannot, at this time be taken to mean available metal in the usual sense.

### 1. Description of Deposits

The manganese formations of Aroostook County are bedded deposits enclosed in fairly old, steeply dipping slates of Middle Silurian (possibly Clinton) age. The manganiferous zones are a few feet to 150 feet in thickness and can be traced for 1 mile or more along the strike. Both the manganiferous beds and the wall rocks are intricately folded and faulted; as a result, the surface trace of the manganese-bearing zone is sinuous and broken.

Exposures are poor over most of the area due to a 3-to 50-foot cover of glacial drift. Once discovered the beds can be traced along the strike by trenching and drilling and to some extent by magnetic and gravity anomalies.

The largest deposit explored to date is on Maple and Hovey Mountain about 18 miles west of Bridgewater, Maine. The most recent exploration of this deposit was begun by the Bureau of Mines in June 1949 and was continued in 1950. By November 1950 the outcrop of the deposit had been exposed at intervals of 50 to 200 feet by trenching and drilling. The total depth and the configuration of the body at depth will be tested by additional deep vertical holes during 1951.

The Maple-Hovey Mountain deposit is a canoe-shaped syncline whose trough contains several minor folds. The northeast end of the syncline crops out on Maple Mountain, the southeast end on Hovey Mountain. Closely spaced trenches and drill holes have recently shown that these two strongly folded segments are connected by a nearly straight segment which extends southwest for the intervening  $3/4$  of a mile. This segment constitutes the southeast limb of the fold whose northwest limb appears to be cut out by a fault. About midway between

these two limbs, the manganiferous zone was cut by a vertical drill hole at a depth of about 1,400 feet.

Three members of the manganiferous zone have been distinguished, each with a characteristic and persistent lithology and manganese and iron content. These members are: (a) An upper zone about 40 feet thick, consisting of purple and red slates interbedded with some greenish slate and banded hematite rock. This member contains an average of 5 to 6 percent manganese and 10 to 15 percent iron. (b) Below the red and purple slates is a zone about 40 feet thick called the banded-hematite zone. As a whole, this is a fairly massive unit which breaks into blocky fragments a few inches to a foot in diameter. Though massive, the rock consists of alternating black and red laminae 1 to 5 mm. in thickness. The principal minerals present are braunite and hematite, whose varying proportions cause the banded appearance. The average grade of the banded hematite zone is 12 percent manganese and 26 percent iron.

## 2. Mineralogy

The only original sedimentary manganese minerals recognized are braunite,  $(3\text{Mn}_2\text{O}_3) \cdot \text{MnSiO}_3$ , and bementite, a hydrous manganese silicate. Other minerals, including manganese-bearing carbonate and rhodonite, are present. The chemical properties of each of the three ore types are summarized in table VII-2.

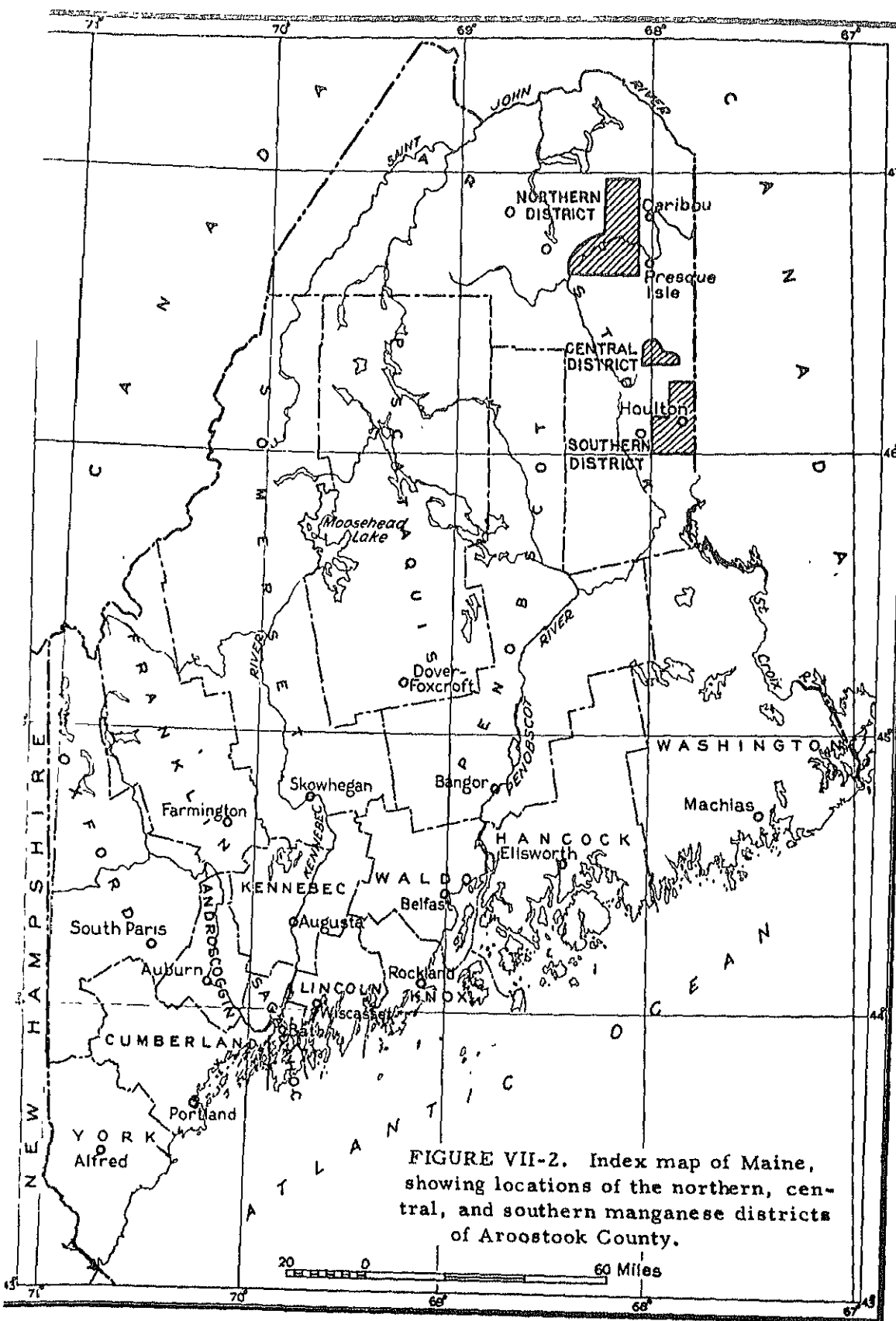
## 3. Reserves

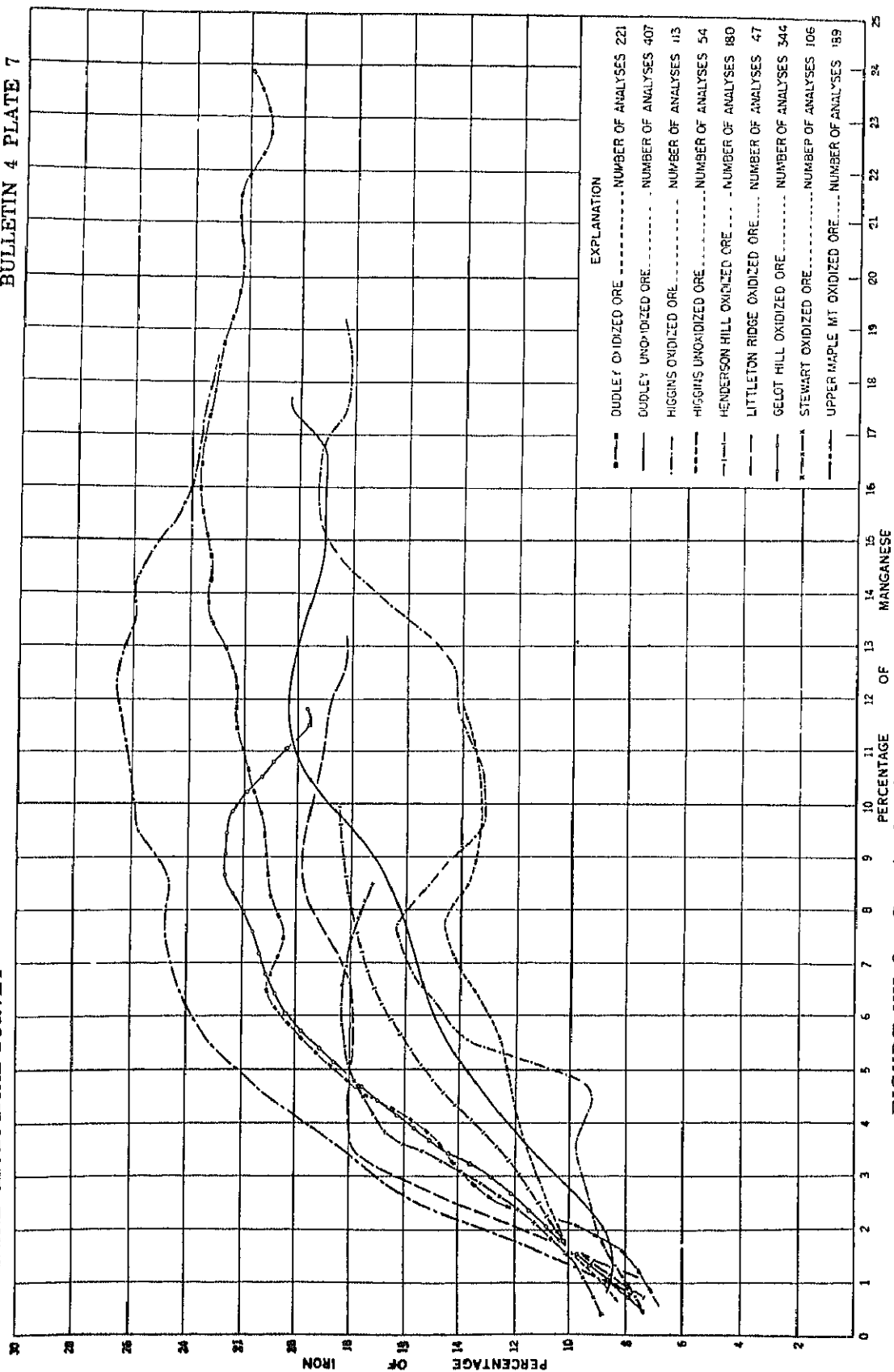
The total tonnage within the Maple-Hovey deposit was estimated by first determining the tonnage as though the bed within the area of outcrop were horizontal. The tonnage for the folded ore body was obtained from this figure by applying a correction factor based on the ratio between the true distance along the folded bed and the horizontal distance across the deposit in a series of cross sections. The resulting figures are summarized in table VII-3. These are preliminary estimates and may be changed appreciably by later work.



TABLE VII - 2. CHEMICAL PROPERTIES OF MANGANESE-BEARING ZONES,  
AROSTOOK COUNTY, MAINE

Element	(1) Red-purple zone			(2) Banded hematite			(3) Transition zone		
	Low	High	Average	Low	High	Average	Low	High	Average
Mn	6.08	6.80	6.4	10.44	14.92	12.09	6.27	7.00	6.63
Fe	10.64	18.55	13.19	23.9	28.27	26.06	15.97	27.34	20.53
P	.246	.486	.393	.91	1.26	1.07	.578	.930	7.54
SiO <sub>2</sub>	38.96	46.18	42.55	20.48	24.6	23.19	29.40	39.92	34.29
CaO	.57	2.32	1.37	3.12	4.07	3.51	1.29	2.60	2.01
MgO	1.31	5.76	2.13	.94	1.76	1.34	1.15	2.73	1.83
Al <sub>2</sub> O <sub>3</sub>	9.69	16.03	12.99	4.85	11.46	6.26	7.86	12.14	10.24
S	.006	.151	.058	.005	.17	.338	.133	.369	.215





VII-13

FIGURE VII-3. Graph showing average percentages of manganese and iron in oxidized and unoxidized ores from seven manganese deposits.

Table VII-3. RESERVES IN THE MAPLE-HOVEY  
DEPOSIT, AROOSTOOK COUNTY, MAINE

Quantity in millions of long tons, (cumulative)	Average grade, percent Mn	Cut-off grade, percent Mn	Total contained Mn	Quantity available by open pit, in millions of long tons
0-100	11-1/2	10	11,500	4,000
0-220	9-1/2	6 <u>a/</u>	19,000 <u>+</u>	14,000
0-300 <u>b/</u>	8 <u>a/</u>	3 <u>a/</u>	21,000 <u>+</u>	32,000

Figures approximate; preliminary estimates.  
Estimated to depth of 1,400 feet below surface.

The above estimate, it will be noted, projects the formations 1,400 feet below surface, a depth already confirmed by one drill hole. With the formations steep-dipping and a maximum of about 150 feet in thickness, it may readily be seen that open-pit mining would win only a small portion of the material and that the bulk (well over 75 percent) of the manganiferous beds would have to be mined by underground methods at relatively high operating costs, since the beds appear too thin to be amenable to lower cost block-caving methods.

Miller's report describes the individual deposits of Aroostook County in considerable detail. In his estimates of reserves, the deposits were projected only to depths of 100 and 200 feet. The accompanying table indicates the relative size of the numerous deposits.

#### D. CUYUNA RANGE, MINN.

The magnetic effects of the iron-bearing formations of the Cuyuna area were first noted in 1883, but it was not until 1903 that the iron ores were finally encountered by drilling. From then on the development was rapid, and only 12 years later, in 1915, shipments amounted to 28,131 tons. Since that time, shipments have continued at the rate of 1-1/2 to 2-1/2 million tons per year, of material which contained 6 percent manganese and 45 to 50 percent iron. The early history and development of the district is well summarized by Zapffe. (10)

Minnesota and extends southwest a distance of about 75 miles. The principal iron ore is found in Iron County, northeast of Brainerd.

with a mantle of glacial drift 25 to 300 feet thick; no natural outcrops are to be seen anywhere in the area.

The manganiferous iron ores are formed by oxidation of primary iron-bearing formation contained in rocks of Pre-Cambrian, presumably Upper Huronian age. (11) Both the enclosing rocks and the iron-bearing horizons have been strongly folded and faulted and dip steeply. As a result, their trace, as determined by mining and drilling, is irregular and sinuous. Until recently, it has been impossible to determine with certainty whether the many parallel ore zones constitute a single bed, repeated by folding, or several beds within a thick series.

The primary ores of the range are of two types : (a) Greenish carbonate slate and (b) cherty iron formation. The green carbonate slate contains 3 to 8 percent manganese, 20 to 30 percent iron, and 25 to 40 percent silica and on oxidation has yielded the so-called "brown ores" (12) which contain about 9 percent manganese, 44 percent iron, 6 percent silica and 0.27 percent phosphorus. The cherty iron formation generally contains more manganese and less iron and on oxidation, yields the so-called "black ores", (13) which contain about 15 percent manganese, 37 percent iron, 15 percent silica, and 0.09 percent phosphorus.

Excluding the material now regarded on the Cuyuna as merchantable manganiferous iron ores, the raw materials available as an emergency source of manganese thus fall into two groups: (a) Unoxidized primary ores, which have never been regarded as a potential iron resource; and (b) oxidized ores, too low-grade to be marketable under prevailing market conditions.

In considering the Cuyuna range as an emergency source of material for concentration to ferro-grade, Grout (14) in 1942 indicated that there are at least 10 million tons of "black ores" of sub-commercial grade, which would be available. More recently Schwartz (15) has estimated that reserves of this type of material to be at least 50 million tons to a depth not exceeding 150 feet. Large tonnages average over 10 percent manganese and an average of 8 to 10 percent manganese would seem conservative for the 50 million tons.

In 1950, Grout and Zinner (16) began to reappraise the manganiferous resources of the Cuyuna range. This study was based on analysis of all the available information concerning the development and extent of the manganese-bearing horizons, supplemented by a .

Table VII-4. SUMMARY OF MANGANIFEROUS RESOURCES,  
CUYUNA IRON RANGE \*

Material	Mining method					
	Open pit (little stripping-easily accessible)					
	Long tons measured	Manga-nese, percent	Long tons indicated	Manga-nese, percent	Long tons inferred	Manga-nese, percent
Carbonate slate	21, 500, 000	6.9	13, 000, 000	3.0	7, 000, 000	5.0
Oxidized material (probably oxidized carbonate slate)	---	---	---	---	---	---
Black-ore formation	---	---	---	---	---	---
Total average	21, 500, 000	6.9	13, 000, 000	3.0	7, 000, 000	5.0

Carbonate slate	---	9.0	105, 000, 000 <u>a/</u>	5.5 <u>+</u>	123, 000, 000 <u>a/</u>	5.0 <u>+</u>
Oxidized material (probably oxidized carbonate slate)	24, 400, 000 <u>b/</u>	3.6	50, 000, 000 <u>b/</u>	3.6	75, 000, 000 <u>b/</u>	3.6
Black-ore formation	53, 000, 000 <u>c/</u>	9.6	28, 000, 000 <u>d/</u>	(6.0-9.0)		
Total average	77, 400, 000	7.7	183, 000, 000	(5.0-5.5)	198, 000, 000	4.5

a/ Open pit; material under 50-80 feet of overburden.

b/ Open pit; material under 150-250 feet of overburden.

c/ Possibly open pit, if underlying carbonate slate belt mined.

d/ Underground, unless open pit widened after mining measured reserves.

\* Grout, D. F., Wood, C., and Lewis, W. E., Progress Report and Preliminary Estimate of Manganiferous Resources on the Cuyuna Iron Range, Minn.: Bureau of Mines, Region V, 1950, (unpublished); released by Paul Zinner, Regional Director, Bureau of Mines.

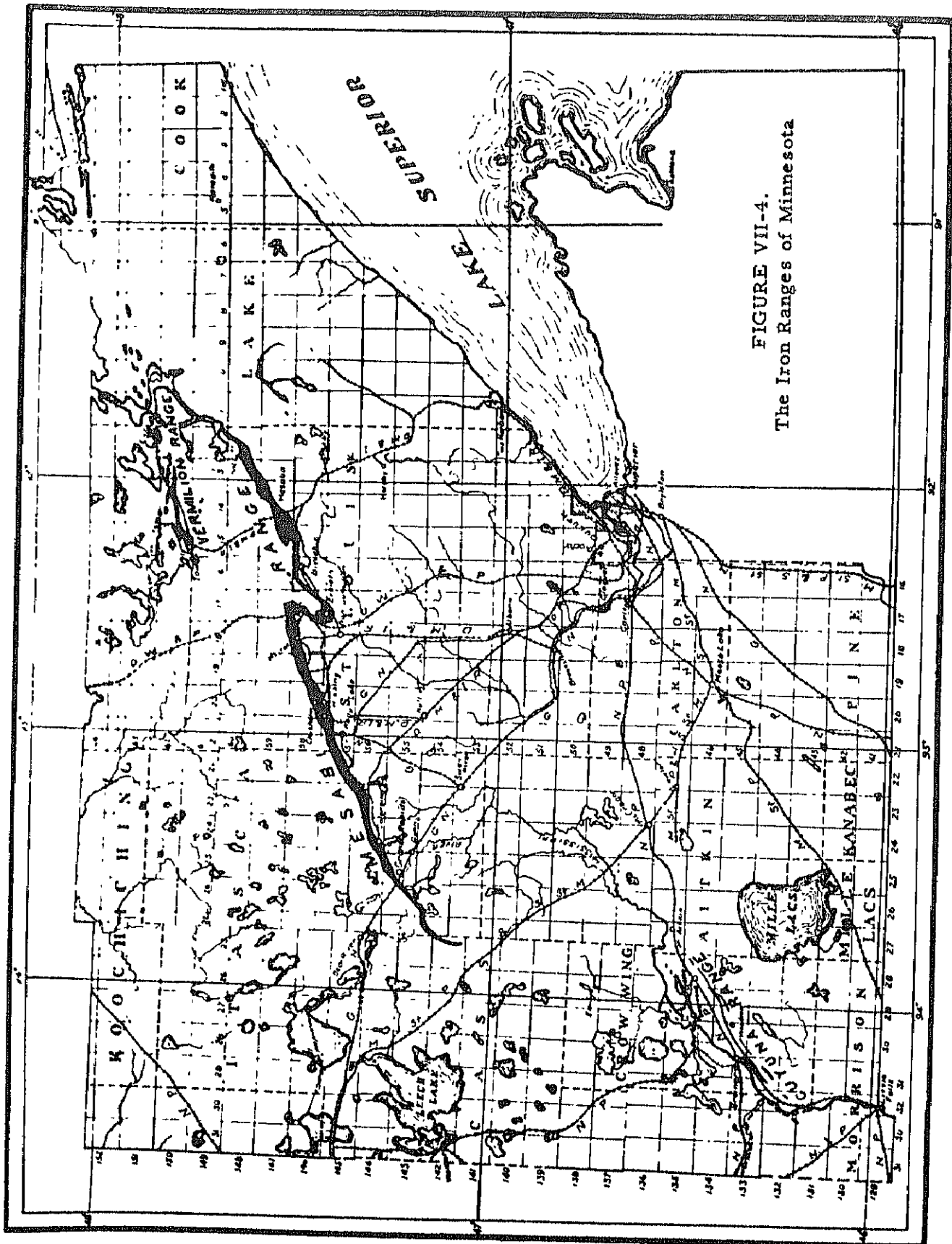
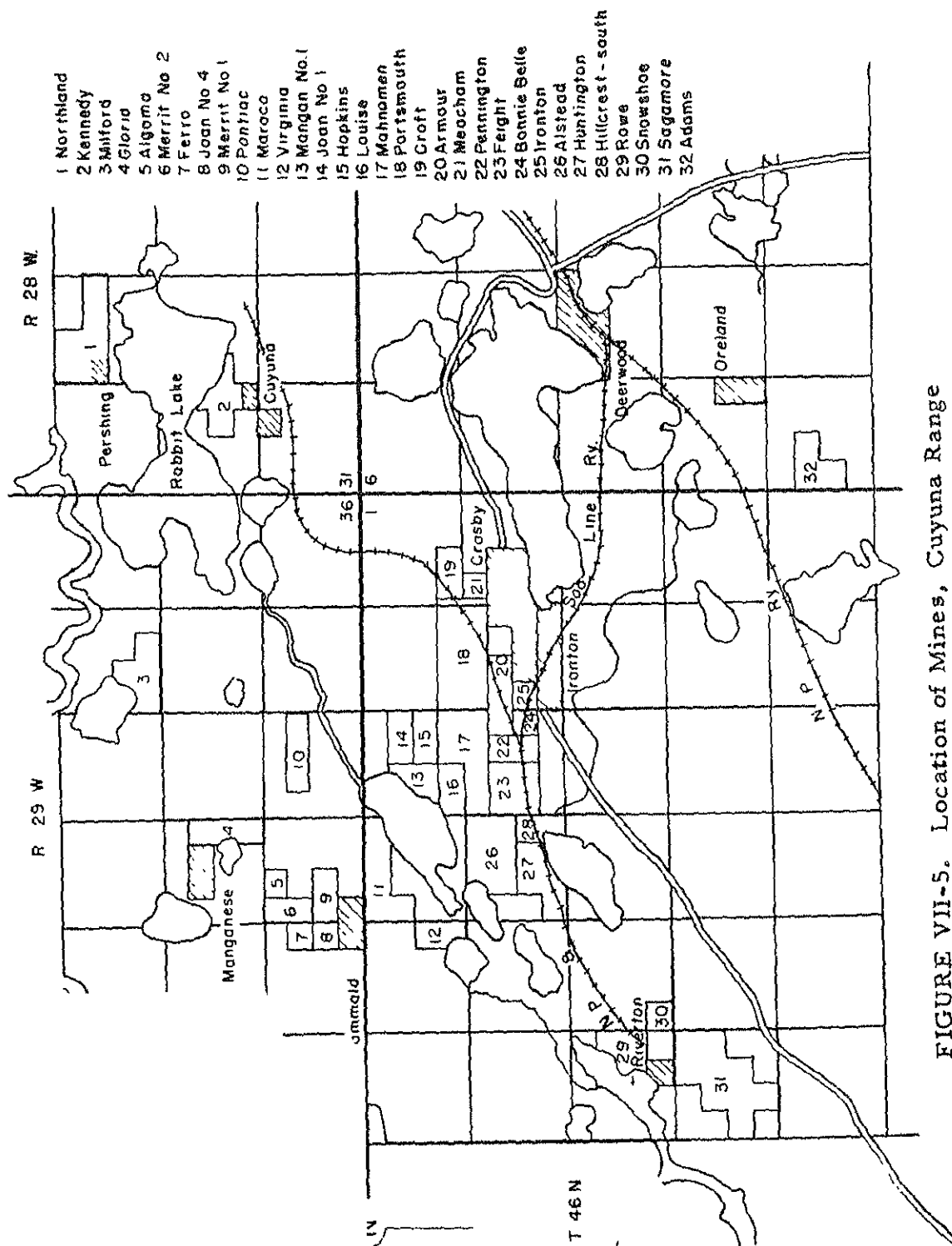


FIGURE VII-4.  
The Iron Ranges of Minnesota





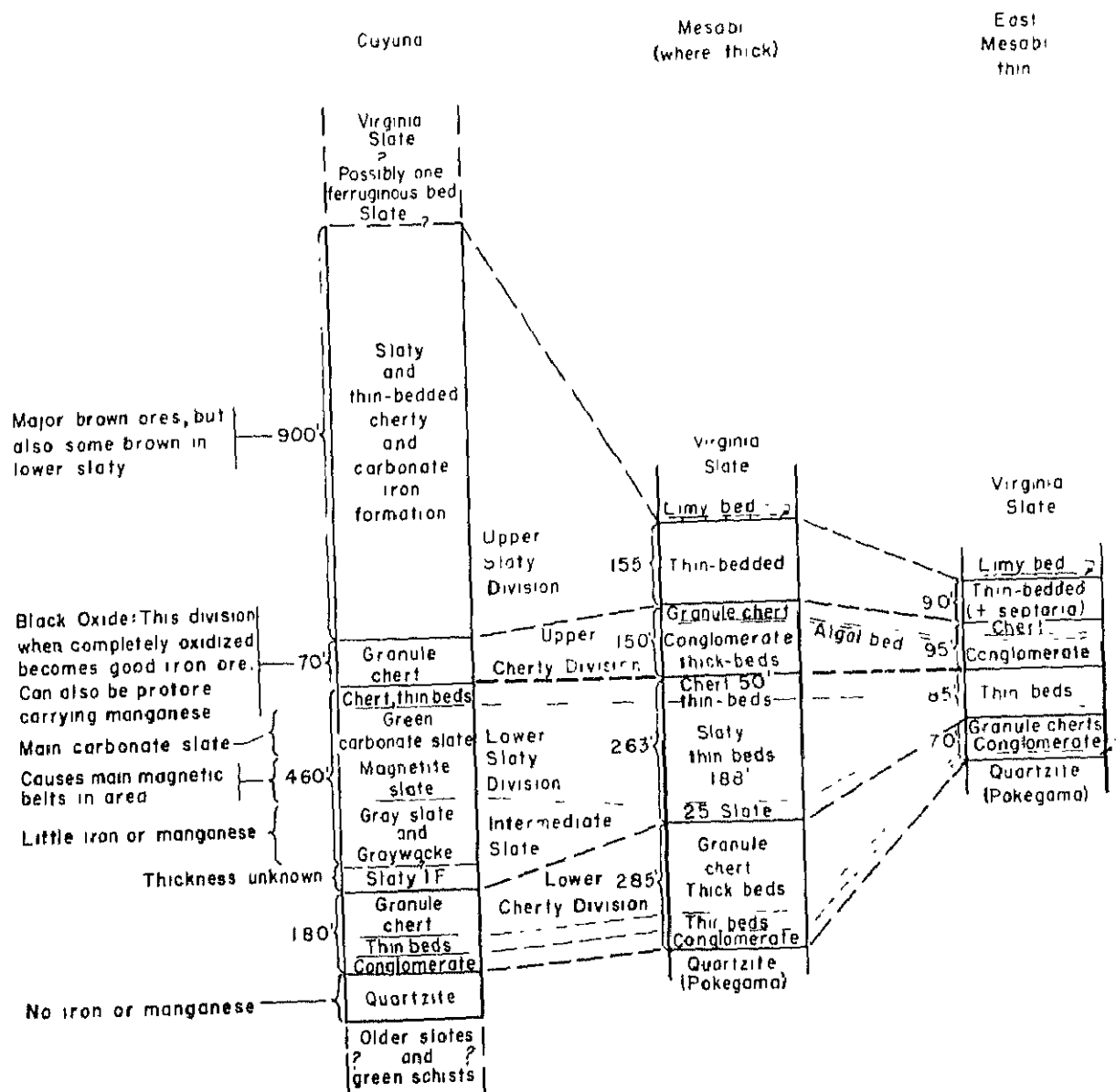


FIGURE VII-6. Cuyuna-Mesabi Correlation Chart



amount of diamond drilling to determine their thickness, grade, and continuity beneath areas of thick glacial cover. The results of this work are summarized in table VII-4.

Utilization of each of the various types of manganese-bearing material presents a somewhat different problem. "Brown ores" may best be used for blast-furnace charge, after sweetening with high-grade iron ores. Siliceous "black ores" and the carbonate-slate appear to offer the most desirable raw material for a process to produce ferro-grade concentrates. Several methods for treatment are available, and study is continuing that should indicate the most desirable method for ultimate use.

## E. LEADVILLE, COLO. (17)

### 1. Reserves

The ore deposits at Leadville, Colo., cover a vertical range of 900 feet in a 1,500-foot thickness of limestones, shales, and quartzites. The manganese minerals form a more or less continuous zone surrounding bodies of lead and zinc ore.

The manganiferous portions run 40 to 55 percent combined manganese and iron (as oxides), 6 to 20  $\frac{1}{2}$  percent silica, less than 0.1 percent phosphorus, and a trace of silver. In addition, enough zinc is sometimes present to be troublesome during blast-furnace treatment.

There are no measurable reserves. Much Mn ore has been left in abandoned mine workings. The estimated reserves are based on the work of several people. They include about 1,000,000 tons of 5 to 35 percent Mn ore (oxidized ore), with another 1,000,000 tons probable. There is also thought to be an additional 2,000,000 tons of mangano-siderite, which, to date, cannot be treated commercially.

## F. NEW JERSEY

The Franklin Furnace area, Sussex County, northern New Jersey, has long been important as a major domestic source of zinc. The deposits are well-known in geological circles also for the unique of oxide and silicate minerals identified there. Franklinite and zincite, are the principal zinc minerals; of these, franklinite  $(\text{Fe Zn Mn})\text{O} \cdot (\text{Fe Mn})_2\text{O}_3$ , containing 10 to 17 percent manganese, is the most abundant, constituting about 40 percent of the ore. The only known occurrence in the world of franklinite and zincite

In the process of concentration, franklinite is separated magnetically, while the remaining zinc minerals are recovered by gravity methods. The franklinite concentrate, upon smelting, leaves a residue similar in composition to an iron-manganese ore. (19) The major portion of this residue analyzes 12 to 14 percent manganese with 40 percent iron and is used to make spiegeleisen; the balance of the residue, containing some 7 percent manganese, is used for making pig iron.

Spiegeleisen was first made as a byproduct of the Franklin ores in 1870. Shipments of spiegeleisen for 1889-1930 totaled over 1,000,000 tons, (20) an average rate of about 100,000 tons per year. In 1926, for instance, 74,096 tons of spiegeleisen were made from 1,374 tons of residues containing 12 percent manganese, while 11,219 tons of low-grade residue running 7.5 percent manganese was used to make pig iron.

In the Franklin-Sterling area, the distribution of ore minerals is known to be remarkably uniform throughout the deposits, and the ratios of Fe:Zn:Mn are surprisingly constant. (21) Although reserve tonnages are not available, the deposits are listed (22) among the major zinc deposits of the United States. It was thought some years ago, (23) in view of the apparent life of the deposits, that output of spiegeleisen could be maintained at the 75,000-ton-per-year-level.

To date, mine production of recoverable zinc in New Jersey has remained relatively uniform for many years.

#### G. BUTTE, MONT. (24, 25)

Butte, like Philipsburg, started as a silver and zinc camp. At present, however, its major production consists of copper minerals. Manganese in the form of rhodochrosite has been known for some time at Butte; for years it was used as road ballast on the property. In 1917-1918 the real value of rhodochrosite was demonstrated, and manganese-ore production at Butte was rapidly increased as a result. Until that time, only a small output of manganese oxides had been realized.

The ore deposits at Butte occur in a complex pattern of fissure veins in a granite (quartz-monzonite) country rock. The minable ores are found in ore shoots within the veins and separated by areas of waste. The metallic minerals occur in a more or less concentric pattern with a well-recognized order. The copper minerals are concentrated in the veins in a central area about 3 miles long and 2 miles wide. Toward the edges, the copper minerals decreased in amount and are

replaced by increasing amounts of zinc and lead minerals; these, in turn, grade into the manganese minerals, which occupy the outer or peripheral zone. The only known portion of the peripheral zone which contains a large enough concentration of the pure carbonate is in the south and southwest sections, wherein lies the well-known Black Chief vein, locally known as the Emma.

Butte veins range in width from narrow stringers to 50 feet. Manganese veins are generally wider near the surface than they are in depth. The minable mineralized length of the main vein is approximately 7,500 feet. Branch veins extend for several hundred feet from it. The ore consists of rhodochrosite, quartz, and altered granite and usually is associated with more or less zinc minerals. The manganese content varies from trifling amounts up to 38 percent, but the higher grades are largely exhausted. At present, ore averaging 18 percent is being extracted and treated.

Ore treatment first involves shipping the ore to Anaconda, where it is crushed, ground, and floated, thereby recovering the sulfide content and concentrating the carbonate. The sulfide concentrates are sent to the zinc plant to recover zinc, lead, etc. The carbonate then assays 38 percent manganese but demands further treatment. It is roasted in a huge, revolving kiln, a process that drives off  $\text{CO}_2$  gas and produces high-grade oxide nodules which assay 60 percent manganese. These nodules are suitable for ferromanganese production, and it is worth noting that, early in 1950, the Anaconda Copper Mining Co. began production of ferro-manganese from these nodules in a plant at Great Falls, Mont.

The classes of reserves at Butte are (a) developed, (b) probable, (c) possible, and (d) prospective. The first three are estimated to amount to something like 2,500,000 tons, based on an 18-percent grade. The prospective reserves amount to 2 and 3 million tons at a grade of 18 percent. If the grade is dropped to 10 percent, there would be added an equal or possibly slightly larger amount of further reserves. The rhodochrosite deposits at Butte probably constitute the largest deposit of their type in the world. As such, they merit especial attention. It is interesting to note, however, that this ore still cannot be treated economically when the content of such metals as zinc, lead, and silver drops below a certain level. The success of the manganese operation at Butte, then, depends to a very large extent upon the sale of byproduct metals, and the ore supply outlined here is based on the premise that it contains the sulfides of these metals in sufficient quantity.

## H. PHILIPSBURG, MONT.

The Philipsburg district, in western Montana, 45 miles northwest of Butte, was originally a silver camp but since 1916 has been the chief source of battery-grade manganese ore in the United States. Manganese was first considered commercially there in 1900, although there were no large shipments until 1916. The total output of high-grade ore (over 35 percent manganese) had amounted by 1940 to around 500,000 tons. Most of the ore is used in making dry-cell batteries, although in national emergencies some has been used for metallurgical purposes also. In addition to the above, 59,817 long tons of manganese carbonate ore was mined and stockpiled between 1942-44.

The principal manganese mines are in a restricted area of about 2 square miles just east of Philipsburg. The country rocks are sedimentary, principally limestones, ranging in age from pre-Cambrian to Carboniferous. These rocks are folded into a broad northwest-plunging anticline whose eastern limb is invaded by granodiorite. Both the sedimentary rocks and the granodiorite are cut by a series of mineralized fissures carrying silver, zinc, and manganese. The largest of these veins are part of a system striking east and dipping steeply south; smaller, less-persistent fissures form a group that strikes north  $60^{\circ}$  -  $70^{\circ}$  west and dips  $60^{\circ}$ - $70^{\circ}$  southwest. A zone of a few inches to a few feet wide along the fissures has been replaced by ore minerals, and the best of these veins have been extensively stoped. In addition, the fissures appear to have been the conduits by which solutions carrying rhodochrosite reached certain horizons which were selectively replaced by manganese. The resulting ore bodies form tabular bedding replacements along the intersection of the host bed and the fissures. From the surface to depths of as much as 700 feet, these ore bodies have been converted to manganese oxides by oxygen in percolating ground water.

Most of the oxide ore mined has contained 30 to 43 percent metallic manganese, but recently ore containing as little as 15 percent has been taken out. The crude ore is milled at Philipsburg to concentrates containing about 70 percent manganese dioxide, which is equivalent to 44 percent metallic manganese. The rhodochrosite ores mined during 1942-44 and more recently have ranged in grade from 15 percent to 30 percent or more. The wartime stockpile of nearly 60,000 long tons averaged 21.87 percent manganese.

Although rhodochrosite ores from Philipsburg are of about the same grade as ores from Butte, attempts to treat the Philipsburg ores by the same flotation treatment used at Butte have been unsuccessful. This is

burg occurs in impure mixed carbonates containing calcium and magnesium, as well as manganese; the grade of such material cannot be raised except by chemical means. (b) Both the ore and the gangue minerals are carbonates, and the flotation method is ineffective for separating them.

Experiments with gravity methods, however, and more recently with magnetic separation promise excellent results.

Although manganese oxides have been mined from the Philipsburg district for more than 30 years, there never has been a substantial developed ore reserve. Generally, new ore bodies have been discovered about as fast as the old ones have been mined, but there has been no long range mining and development program. As a result it is necessary to estimate the potential reserves of oxide ore on a statistical basis. In 1940 Goddard, (26) using methods of this kind, arrived at the figure of about 600,000 tons of oxide ore averaging perhaps 30 percent manganese. The decreased rate of discovery during the years since the war and the fact that several of the more important ore bodies have been mined down to the level of primary ore suggest that this figure may be somewhat too large. Nevertheless, it is probable that, with energetic prospecting and a continued market, the district can continue to produce a few thousand tons of battery-grade ore per year for many years.

As in the case of the oxides, there are no developed reserves of manganese. Nevertheless, rhodochrosite ores are exposed or are known to exist in at least six important mines, and there is every reason to expect that these, plus other undiscovered ore bodies nearby, may contain at least 500,000 tons of material with an average grade of 20 percent manganese.

## I. BOULDER CITY, NEVADA

Bedded manganese oxides of the same type as those at the Three Kids deposit occur about 5 miles southeast of Boulder City. The manganese occurs in a bed of silty gypsum 60 to 65 feet thick. Exploration by the Bureau of Mines and the Geological Survey in 1941 and 1942 showed a reserve of 14 million tons of material averaging 3 percent Mn and 1 million tons averaging 7-1/2 percent Mn.

## J. PIOCHE DISTRICT, NEVADA

Deposits of manganiferous iron ore in the Pioche district, Nevada have been described by Knopf (27) as replacement deposits in limestone consisting of a core of silver-lead ore, surrounded by successive zones which are progressively higher in manganese. Above the water bed, these bodies consist of a mixture of manganese and iron oxides, containing about 30 percent iron and 15 percent manganese, 3 percent lead, and 2 to 3 ounces of silver per ton. In 1926 this ore was being shipped to the Columbia Steel Co. plant at Provo, Utah, at the rate of 1,900 tons per month and more than a million tons has been shipped in total. Below the water table, the ore consists of a very coarse grained manganiferous siderite containing 27 percent or more FeO and 24 percent or more MnO.

There is no record of the amounts of these ores available now; however, it is believed that there are at least a million tons of oxidized material, with good prospects for double that amount of unoxidized material.

## K. THREE KIDS DISTRICT, NEVADA

The Three Kids manganese district, in the southern tip of Nevada, 10 miles northwest of Boulder Dam and 15 miles southeast of Las Vegas, produced some 15,000 to 20,000 tons of manganese ore at the close of World War I and has since been largely idle. The open-pit ore of the Three Kids claim, which ran 30 to 40 percent manganese, 1-1/2 percent iron, and 12 percent silica, was exhausted by 1920. Since 1940 the Three Kids, Annex, and Las Vegas claims have been explored by diamond drilling by M. A. Hanna Co., Western Minerals Exploration Co., and the Federal Bureau of Mines. During 1942-44, more than 350,000 tons of material averaging 25.81 percent manganese were mined and stockpiled at the Three Kids property. Several tons of this were treated by SO<sub>2</sub> leaching in a 1,200-ton mill. Most of it, however, remains on the stockpile.

Manganese reserves in the Three Kids district have been estimated by the Federal Geological Survey (28) at a total of 5,500,000 tons of material averaging over 10 percent manganese, including some 800,000 tons running over 20 percent - probably close to 25 percent - manganese and 4,700,000 tons of 5 to 20 percent material that probably would average 7 or 8 percent manganese. This estimate does not include material of less than 5 percent manganese content. Tonnage was estimated on the basis of 20 cubic feet per short ton for material in place in the ground.



In general, the low-density material carries the high manganese content of 30 to 40 percent, whereas the heavy, high-density material is of low manganese content - less than 10 percent.

The manganese deposits of Clark County occur in sedimentary rocks and consist of irregular bodies of wad (hydrous manganese oxide of variable composition) interbedded with lake-bottom sediments. The manganiferous horizon is 10 to 75 feet in total thickness, more often 25 to 40 feet thick, and is known to persist for at least 6 miles. Some manganese oxide is found outside the main zone as in lenses (rarely over 6 inches thick) in the underlying conglomerate and in the overlying gypsiferous red beds. Where the manganese content is as much as 30 percent, the wad is found as thick, massive beds separated by nearly barren partings. In areas of low manganese content, the wad occurs as thin, irregular lenses scattered throughout the sandstone or as cement for the sand grains. The manganese content of the beds is not constant; it is known to change for the beds as a whole by as much as 3 percent of manganese in 5 feet laterally and within individual lenses by as much as 15 percent of manganese in 5 feet. The most concentrated deposits appear to be associated with fault blocks displaced before deposition of the manganese minerals. At the Three Kids, where the best grades have been found, the grade diminishes outward in all directions. Similar peaks of grade concentration are found at the Las Vegas shaft and the Las Vegas extension area to the southwest.

A complete analysis of the ore from the Three Kids mine was given by Jones (29) in 1920, as follows:

Analysis of Manganese Ore From Three Kids Deposit, Percent  
(Smith, Emery & Co., Los Angeles, Calif., analysts)

MnO <sub>2</sub> -----	56.04	MgO -----	1.41
MnO	7.08	CuO -----	.49
Fe <sub>2</sub> O <sub>3</sub>	1.68	ZnO	None
Al <sub>2</sub> O <sub>3</sub>	1.85	P <sub>2</sub> O <sub>5</sub>	.07
SiO <sub>2</sub>	13.73	SO <sub>3</sub>	.43
PbO	2.07	As <sub>2</sub> O <sub>3</sub>	.06
BaO	.02	K <sub>2</sub> O + Na <sub>2</sub> O	3.82
CaO	Trace	H <sub>2</sub> O by diff.	11.25

## L. GAFFNEY - KINGS MOUNTAIN NORTH AND SOUTH CAROLINA

Millions of tons of material containing perhaps 5 to 8 percent manganese, mostly in the form of spessartite, are known to occur in a narrow belt of folded rocks extending across the boundary of North and South Carolina in a northeast direction between Gaffney and Kings Mountain. These deposits were recognized by Kuth (30) and others as early as 1910, and interest in them has been renewed every time there has been a shortage of foreign ores. The most-recent and complete summary of the occurrence is by White. (31)

Manganese deposits occur in an ancient sericitic or graphitic schist, the Battleground schist of probable pre-Cambrian age. Near the top of this formation is a horizon characterized by the presence of quartz-spessartite (manganese garnet) lenses and stringers. The manganese is not uniformly distributed along the above horizon, but occurs in elongated zones 1,000 to 2,000 feet in length and 75 to 300 feet in width. Barren intervals of equal length separate the mineralized zones, and occasionally two parallel zones may be present, 500 to 1,000 feet apart across the strike.

The primary manganese mineral spessartite has partly broken down under the influence of the humid climate, and the resulting manganese oxides thoroughly stain the outcrops of the manganiferous zone and adjoining parts of the barren schist. Even at the surface, oxidation of the primary material is incomplete, and a large percentage of the contained manganese is probably in the silicate mineral.

Undoubtedly a few tens of millions of tons of manganiferous material exist in this area. The average manganese content, judging from the assays reported by White (32) is 3 to 4 percent manganese. However, until some means is devised of recovering the manganese from these silicate minerals, these materials will remain only a potential resource.

## M. CHAMBERLAIN, S. DAK. (32)

Extensive deposits of manganese-bearing concretionary shales outcrop along the Missouri River and its tributaries in South Dakota. Exposed deposits extend from Pierre, south to the Nebraska State Line, a straight-line distance of about 120 miles. The area is easily accessible, being served by two major railroads and three Federal highways. Locally, however, the region is relatively undeveloped and until

connecting roads are constructed, travel will be difficult at best; off-highway travel is impossible during inclement weather.

The manganese deposit itself is one member in a thick series of concretionary shales; the bed is made up of alternating bentonite, bentonitic shale, and manganese-iron carbonate concretions. The concretions form discontinuous layers 1 to 9 inches thick. The concretion content of the entire zone is 1 to 7-1/2 percent, averaging 3.78 percent, and the concretions contain 4 to 25 percent manganese, averaging about 15-1/2 percent.

There are two types of concretions, based on hardness. The hard ones, which are more abundant, have a hardness of about 4.0 to 5.0 on the Mohs scale and average 1 to 2 inches in thickness by 1 to 6 inches in diameter. The biggest reach 8 inches in thickness by 24 inches in diameter. The soft concretions have a hardness of 2.5 to 3.5, and their maximum size is 2 inches in thickness by 4 inches in diameter.

Generally speaking, the manganese content of the concretions goes up as the iron content goes down. The greatest number of analyses fall between the following three limits: (a) 13.4 percent Mn, 14.4 percent Fe; (b) 16.0 percent Mn, 2.4 percent Fe; and (c) 21.6 percent Mn, 4.0 percent Fe. There is a clustering of analyses around two major points: 14.5 percent Mn, 12.6 percent Fe, and 18.7 percent Mn, 3.2 percent Fe.

Along 523 miles of river banks there is a weighted average outcrop width of 190 feet. By stripping on a 1/2:1 ratio (that is, 1/2 cubic yard of overburden to 1 ton of ore), this width can be extended to 365 feet. In this zone are 2,055,469,000 tons of shale (dry) containing an estimated 77,754,000 tons (dry) of nodules. These nodules, averaging 15.51 percent Mn, contain 12,058,254 tons of metallic manganese. There are thus about 77 pounds of nodules and 12 pounds of manganese per short ton of shale. The reserve estimates are based solely on the measured outcrop width plus that which could be exposed by stripping on a 1/2:1 ratio. Considering the fact that the manganiferous bed outcrops as far back from the river as 25 miles and disregarding overburden, it is easily seen that the estimates can be revised upward several times.

To date, mining of this bed has not been attempted on a commercial scale. However, the Bureau of Mines had a pilot plant at Chamberlain where beneficiation tests have been conducted. The Metals Reserve

Company has used the facilities of this plant, and its work, along with that of the Bureau, has led to the conclusion that the manganiferous bed can be mined and the material processed, but at a cost now prohibitive. The big problem is separation of the nodules from the shale. Because the material as mined contains 15 to 20 percent moisture and because the shale becomes extremely gummy and adherent when wet, ordinary crushing and screening are precluded. Drying of the material also is not practical because of the high percentage of shale per unit of material mined (about 96 percent, on the average). The only recourse is especially intense jigging, followed by washing with high-pressure water streams and then screening. Even this cannot as yet produce a really clean product. In spite of these difficulties, however, the deposit constitutes a major potential domestic source of supply in extreme emergency.

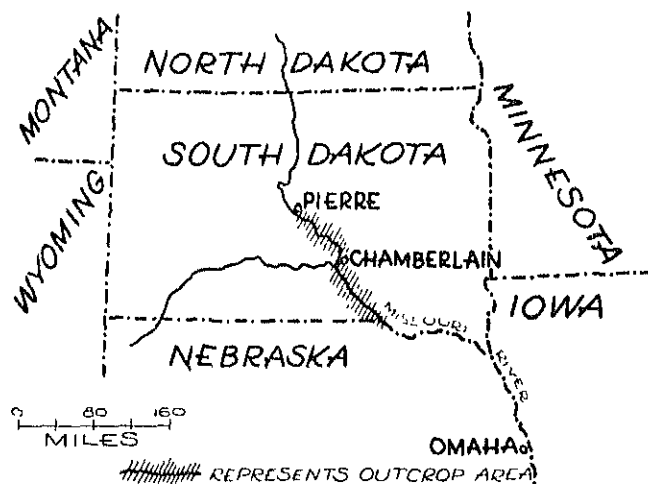


FIGURE VII-8. Low-grade manganese deposits near Chamberlain, S. Dakota.

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## VIII. NORTH AMERICA



## CHAPTER VIII NORTH AMERICA

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## VIII. NORTH AMERICA

### A. CANADA

Known deposits of high-grade manganese ore in Canada are considered (1) small and largely exhausted. Production in the past has come mainly from Turtle Creek, Albert County, New Brunswick, with small amounts from Lunenburg, Nova Scotia.

In 1947, bog manganese ore was produced for chemical use from deposits near Renous, Northumberland County, New Brunswick. Recently, also, development work has been reported on a deposit on Grindstone Island of the Magdalen Group, and a manganese-bearing bed of unspecified content, 2 feet thick, has been reported (2) at the Steep Rock iron mine, north of Lake Superior.

### B. COSTA RICA (3)

Costa Rica was a minor producer of manganese ore during World War I, reaching a peak of approximately 10,000 tons in the years 1918-19. Since then, production has dwindled to a few hundred tons in occasional years, with no recorded production of record since 1938.

The manganese deposits of Costa Rica lie along the Pacific coast on the Nicoya Peninsula, in the Province of Guanacaste. They have been described as consisting mainly of small lenses of manganese silicate minerals in sedimentary and igneous rocks, as well as irregular residual oxide deposits from the weathering of silicates.

Most of the ore mined to date has been oxide from surface deposits. The old workings are largely inaccessible. Reserves are considered small - a few thousand tons that could be sorted or concentrated for export.

### C. CUBA

Manganese ore has been found in every Province in Cuba, but most of the ore produced has come from Oriente, at the eastern end of the island. The majority of the deposits in this province are situated on either the north or the south slope of the Sierra Maestra. In addition ore has been exploited in Pinar del Rio Province (at the west end of the island) and in Las Villas (Santa Clara) Province in central Cuba. Deposits are also known on the Isla de Pinos, and in the Provinces of Camaguey, Mantanzas, and Habana.

The deposits have been classified (4) according to rock environment primarily, with some consideration of form, as follows:

1. Deposits in tuff. Examples: The mines near El Cristo and the Bueycito mines, Oriente.
2. Deposits in limestone. Examples: La Unica mine and Charco Redondo mine, Oriente.
3. Granzon, or surficial layers of manganiferous granules and pellets in soil. Examples: La Gaceta mine, Oriente, and La Cuca mine, Pinas del Rio.
4. Miscellaneous deposits. belonging to none of the first three classes.

#### 1. Deposits in Tuff

These are the most abundant in Oriente and consist of grains, nodules, pockets, and veinlets of manganese oxides irregularly distributed through beds of altered tuff. At some properties (for example, the Quinto pit and the Ponupo mine) entire beds up to 20 feet or more in thickness are mined over large areas. Usually, however, the ore bodies are lenticular or irregular. Contacts with country rock usually are gradational. These deposits are large and more uniform, in general, than the other types and consequently have yielded most of the manganese ore produced in Cuba.

#### 2. Deposits in Limestone

Deposits in limestone occur chiefly in Oriente, along the northern slope of the Sierra Maestra, but they are also known in Pinar del Rio and in Las Villas. A few ore bodies are large, well-defined lenses, but more often they are small pockets of ore where stringers of manganese oxides widen or coalesce. In some places manganese oxides cement limestone breccia; in others, fragments of ore are found surrounded by limestone. At the Charco Redondo mine, layers of manganese oxides up to 4 feet in thickness occur between beds of limestone. Another layer 6 inches to 2 feet thick has been traced for more than a mile along the strike. Some of the ore bodies contain 25,000 tons or more of ore, but most of them yield little more than 100 tons.



### 3. Granzon

Granzon is a term applied to ore consisting of nodules or pellets in soil and subsoil. These pellets usually are made up of concentric layers of manganese oxides and are generally less than 1 inch in diameter. To be considered ore, they must constitute more than 10 percent of the soil. Granzon is found principally near the outcrops of other types of ore. Granzon should not be confused with laterite; it is not derived from the decomposition of large masses of rock, as are laterite and bauxite. The ore is easily recovered with a small capital investment, and the concentrates are of better grade than the other varieties of ore. For these reasons, granzon is much sought and is commonly the ore first mined in a district.

Cuban manganese ore deposits have also been classified according to mode of occurrence, (5) as follows:

1. Bedded ores.
  - A. Tuff ores
    - (1) Oxide ores
    - (2) Silicate and high-silica ores
  - B. Limestone ores
  - C. Mezclado ores
2. Nonbedded or irregular ores.
  - A. Adjacent to faults
    - (1) In limestone
    - (2) In volcanic rocks
  - B. In irregular fracture zones
    - (1) In limestone
    - (2) In volcanic rocks (for example, basalt)
    - (3) In plutonic rocks (for example, granite)
3. Surficial ores
  - A. Cave ores
  - B. Granzon or shot ore

The only new term here that is not self-explanatory is "mezclado," by which is meant a conglomeratic ore that is intraformational in the limestone. The conglomerate is made up of blocks and fragments of manganese ore from the underlying tuffs, limestone, tuff, algal heads, etc., in a matrix of limestone. It is this kind of ore that was spoken of (above) as "fragments of ore . . . surrounded by limestone."

The evidence for the mode of origin of Cuban manganese ores seems, at first glance, contradictory. Manganese oxides cement

limestone breccias, but limestone cements fragments of ore; manganese oxides penetrate and replace portions of tuff beds, but veinlets of tuff are found in ore. These conflicting facts have been interpreted (6) to mean that the ores are in part original sediments and in part replacement products resulting from ascending underground hot waters. In other words, part of the ore originated before the associated sedimentary rocks, and part of it was introduced afterward.

Mineralogically, Cuban manganese ores are simple. The principal ore minerals are pyrolusite, psilomelane (mostly of the variety cryptomelane), and manganite. Braunite and orientite, a complex hydrous manganese silicate, are known but unimportant. The ore minerals are associated with calcite, cryptocrystalline (extremely fine-grained granular) silica in the form of jasper, and a red or pink, soft, soapy mixture of kaolinite, zeolites, and calcites.

Mining is done either underground or in open-cuts. The workings are usually small and irregular, because of the irregularity of the ore bodies. Hand mining and hand sorting are much more in evidence than are mechanical methods.

As recently as the summer of 1950, Cuban manganese ore reserves were estimated (7) to be adequate to maintain production at the rate of about 50,000 tons a year for 4 to 6 more years. Through beneficiation of low-grade ores, this production could be trebled. For a longer period, production depends on the discovery of new reserves or the extension of known ones. Present known reserves might be more than doubled by prospecting and exploration of several mines and areas considered favorable.

#### Geology and Classification of the Manganese Deposits

Oriente Province: The manganese deposits of Oriente Province (8) are confined entirely to explosive volcanic rocks or minor limestone beds of the Eocene Cobre formation. Most of the deposits are in the upper part of the formation; the largest deposits are in the uppermost 30 meters, and nearly all of them are in the upper 300 to 400 meters of the formation. The majority of the deposits are tabular bodies paralleling the bedding of the enclosing rocks; many occur in or near limestone beds but commonly are separated from the limestone by a thin layer of barren volcanic rock. The few nonbedded or irregular ore bodies that transect the enclosing beds have relatively minor importance. A minor amount of ore has been mined from residual surficial deposits formed by weathering of the primary ore deposits. In some of the nonbedded deposits, faults have been important structural

controls, but faulting associated with the bedded deposits is believed to be postmineral in age. Park (9) first suggested, and the writers concur, that the bedded deposits are syngenetic, formed at or about the same time as the enclosing volcanic ejecta were laid down.

The primary manganese minerals of the principal deposits are oxides of the psilomelane group, and all the deposits contain variable amounts of the secondary oxides pyrolusite and manganite. Deposits containing manganese silicates in association with primary or secondary oxides are not commercially important, though they may have future value.

**Las Villas Province:** The manganese of the Quemado district in Las Villas Province occurs in extensive residual deposits derived from the weathering of manganiferous chert and impure limestone of upper Jurassic (?) or lower Cretaceous (?) age. Manganese oxides (wad or impure pyrolusite and a little psilomelane-type material) form pebbles and nodules in lateritic soil.

**Pinar del Rio Province:** Park (10) reports that most of the manganese deposits of the Pinar del Rio Province "are in the shaly San Cayetano formation, but there are small bodies in the massive Vinales limestone . . . . ."

### Production

Annual production of manganese ore from 1888 to 1940 is shown in table VIII - 1; the period 1940 to 1949 is shown in table VIII - 2. A maximum production of 306,298 long tons of metallurgical ore, including both sintered and nonsintered ore, was attained in 1943. Output decreased markedly during the latter part of the war period; this decrease is attributed mainly to a reduction in available reserves of ore. The marked drop in 1945 reflects, in addition, a lowered demand for ore, which resulted in imposition of tighter purchase specifications. To some extent, depletion of known reserves in 1945 was abnormally high because mine development and exploration were restricted owing to a general lack of optimism concerning future market conditions.

Since 1945 the total annual production has continued to decrease. The greatest drop in production occurred when the mines and sintering plant of the Cuban Mining Co. (11) were permanently closed on December 31, 1946, because of exhaustion of ore available for open-pit mining operations; as may be seen in table VIII - 2, more than half of the ore produced from 1942 to 1946 was sintered ore. The postwar peak production of nonsintered ore (61,516 tons in 1949) appears to be the

result of greater demand for ore.

Table VIII- 1. PRODUCTION OF MANGANESE  
ORE FROM CUBA, 1888-1940 /1

Page 1 of 2

Year	Long tons /2	Value /2
1888-96 .....	/3 77,228	\$695,393
1897 .....	/4 6,992	81,126
1898 .....	1,600	8,026
1899 .....	16,359	221,785
1900 .....	20,582	259,348
1901 .....	21,627	307,084
1902 .....	36,294	285,571
1903 .....	17,721	111,670
1904 .....	16,239	80,974
1905 .....	6,489	35,049
1906 .....	11,701	117,050
1907 .....	30,006	262,847
1908 .....	1,469	13,489
1909 .....	2,950	11,800
1910 .....	2	26
1911 .....	0	0
1912 .....	0	0
1913 .....	0	0
1914 .....	0	0
1915 .....	5,141	69,453
1916 .....	30,563	514,184
1917 .....	44,511	612,413
1918 .....	82,974	2,751,193
1919 .....	35,320	1,433,202
1920 .....	8,247	266,744
1921 .....	34	679
1922 .....	12,568	89,677
1923 .....	9,062	137,016
1924 .....	23,065	347,874
1925 .....	12,747	253,315

Table VIII - 1. PRODUCTION OF MANGANESE  
ORE FROM CUBA, 1888-1940 /1

Page 2 of 2

Year	Long tons /2	Value /2
1926 .....	14,112	224,523
1927 .....	8,976	141,830
1928 .....	3,180	60,402
1929 .....	2,667	32,654
1930 .....	2,071	32,317
1931 .....	3,804	/5 19,891
1932 .....	6,749	111,770
1933 .....	28,257	430,906
1934 .....	63,743	965,610
1935 .....	43,955	700,493
1936 .....	37,912	521,809
1937 .....	122,937	2,185,800
1938 .....	131,422	2,242,425
1939 .....	105,936	1,689,547
1940 .....	130,646	3,059,735
Total .....	1,237,858	21,386,706

/1 Ore containing 35 percent or more manganese.

/2 Figures from the Bureau of Foreign and Domestic Commerce.

/3 Exports from Cuba.

/4 Imports into the United States from Cuba.

/5 This is the figure recorded, but it seems low.

Year	Nonsintered metallurgical-grade ore (average grade, about 45% manganese)	Sintered metallurgical-grade ore (average grade, about 50% Mn)	Chemical grade ore (average grade, about 82-83% MnO <sub>2</sub> )	Total production	Year
1940	<u>1</u> 130,646			130,646	1940
1941	<u>1</u> 243,405			243,405	1941
1942	104,573	140,745		245,318	1942
1943	145,008	161,290		306,298	1943
1944	120,295	133,496		253,791	1944
1945	64,639	130,236	<u>3</u>	194,875	1945
1946	35,054	88,123	5,521	128,698	1946
1947	43,144	<u>2</u>	4,766	47,910	1947
1948	23,531		4,382	27,913	1948
1949	50,534		10,982	61,516	1949

Total production, 1940 - 1949: 1,640,369 long tons.

1 Imports from Cuba; includes sintered ore.

2 Sintering plant of Cuban Mining Co. ceased operations Dec. 31, 1946.

3 Purchases of chemical-grade ore initiated in 1946.

From 1942 to 1945 more than 95 percent of the ore produced was obtained from 17 mines or mine groups, each of which produced over 6,000 tons of ore. These mines, with their total production from January 1942 to August 1945, are listed in table VIII-3. By far the largest quantity of ore was obtained from the Quinto and Ponupo mine groups of the Cuban Mining Co., which together accounted for about 56.5 percent of the total production in the form of sintered concentrates, approximately two-thirds of this ore came from the Quinto group. By 1945, nine of the mines listed (Boston, Bueycito, Cadiz, Casualidad, Montenegro, Ponupo de Manacal, Taratana, Unica, and Yeya) were producing either no ore or but a fraction of their former output owing to near or complete exhaustion of their reserves of economically recoverable ore. These nine mines accounted for about 19.5 percent of the total ore produced during the period 1942-45.

Three classes of ore have been shipped from Cuba: Hand-sorted or untreated ore, washed and jigged ore, and sintered flotation concentrates. Cuban manganese ores range from 42 to more than 50 percent manganese, as shipped, and deleterious elements are present in negligible amount. Nonsintered ores which range from 42 to 52 percent manganese contain an average of 7 to 8 percent silica and 2 to 3 percent iron; the sintered ores range in grade from 49 to 50 percent manganese and contain 8 to 10 percent silica. It is noteworthy that the great bulk of shipping-grade ore must be concentrated by methods other than hand sorting; the approximate relative amounts of ore produced in each class from 1942 to 1945 were as follows:

Hand-sorted ore	18 percent
Washed and jigged ore	26 do
Sintered concentrates	56 do

Ore of metallurgical grade only was produced during the period 1942-45, but in 1946 the Tennessee Eastman Corp. initiated the purchase of chemical-grade ore, specifying a pyrolusite-type ore of low lime content. According to the consular reports of the American Embassy in Habana, Cuba, prepared by Albert Horn, 25,651 tons of chemical-grade ore were produced during 1946-49. The bulk of this production probably came from the following mines: Amarito (Manacas group), Antonio, Espana-San Luis-Tordera group, Llava, and Pozo Prieto group.

Table VIII-3. PRODUCTION OF LARGEST MINES IN ORIENTE PROVINCE, IN LONG TONS, JANUARY 1942 - AUGUST 1945.

Mine	Total production	Approximate average grade, percent Mn
Antonio	/1 10,000	43
Boston	7,412	44
Briseida	10,954	46
Bueycito	12,727	47
Cadiz	/1 10,000	43
Casualidad	/1 25,000	43
Charco Redondo	40,519	44
Espana-Portugal-		
San Luis-Tordera group	76,110	46
Llave	6,908	51
Manacas group	9,869	51
Montenegro	9,352	41
Ponupo de Manacal	6,963	43
Quinto-Ponupo group	/2 37,705	45
Quinto-Ponupo group	/3 565,767	50
Taratana group	90,289	46
Unica	/1 20,000	43
Yeya	/1 15,000	48

/1 Estimated production.

/2 Nonsintered ore from Cuban Mining Co. properties.

/3 Sintered ore from Cuban Mining Co. properties.

### Reserves

Manganese deposits in Cuba are believed to contain reserves of high-and medium-grade ore sufficient to yield 300,000 to 750,000 long tons of hand-sorted ore and jig concentrates averaging 42 to 50 percent manganese. In addition, there are 2,000,000 to 3,000,000 long tons of low-grade ore that can be treated by flotation. These reserves are sufficient to yield approximately 1,000,000 long tons of sintered concentrates.

In general, known reserves declined steadily during 1943 - 45, when 18 mines, either exhausted their reserves of mineable ore or depleted their reserves to such an extent that production dropped to a small fraction of its former amount. Reserves probably could be increased substantially by intensive exploration in known favorable areas.



## Outlook

**Future Production:-** The present production rate of about 50,000 tons per year can probably be maintained for 4 to 6 years more, to judge from past experience and estimated reserves, but without added incentive in the form of price increases and some assurance of continued demand, it doubtless will not increase markedly. Present prices are higher than those paid during 1942-45 and are decidedly more favorable to the Cuban ores; the greatest price increase has been in the lower-grade brackets (40 to 45 percent manganese) which include the bulk of the Cuban nonsintered ores. But costs are probably higher.

Production is probably now maintained chiefly by the Charco Redondo, Espana-San Luis-Tordera, Llave, Manacas, Ponupo and Pozo Prieto mines. Of these, probably only the Charco Redondo, Manacas, and Ponupo mines could increase their output immediately. However, experience has shown that established mine operators are extremely reluctant to expand their operations without assurance of continued demand at stable prices. Moreover, most operators have limited capital at their disposal and therefore must expand operations slowly. Production might be increased by 10,000 to 20,000 tons annually under the stimulus of present demand.

Any substantial production increase must be brought about by utilization of low-grade ores, of which large reserves are known. A flotation and sintering plant at the site of the former plant of the Cuban Mining Co. at El Cristo could utilize ores from the Quinto, Ponupo, Jutinicu, and Sabanilla districts. However, utilization of the large reserves of the Quinto and Ponupo mines would require underground mining, as the ore lies at depths of 140 to 300 or more feet; the shallow ores were exhausted by the open-pit operations that ended in 1946. It is doubtful if present prices (1950) are high enough to induce private interests to invest in a large concentrating plant and in a program of exploration and development. Utilization of the low-grade reserves of the Casualidad and Bueycito mines might be realized by erecting small flotation mills at these mines and by sintering the flotation concentrates at a central plant at El Cristo. Neither of these properties could support a combined flotation and sintering plant.

Just what price increase would be necessary in order that the Quinto, Ponupo, and other low-grade ores might be exploited would have to be determined by an analysis of the costs of underground mining compared with open-pit mining and of costs of labor and supplies. Exploitation of these deposits, whose measured and indicated reserves are 1,500,000 to 1,775,000 long tons and whose estimated inferred reserves

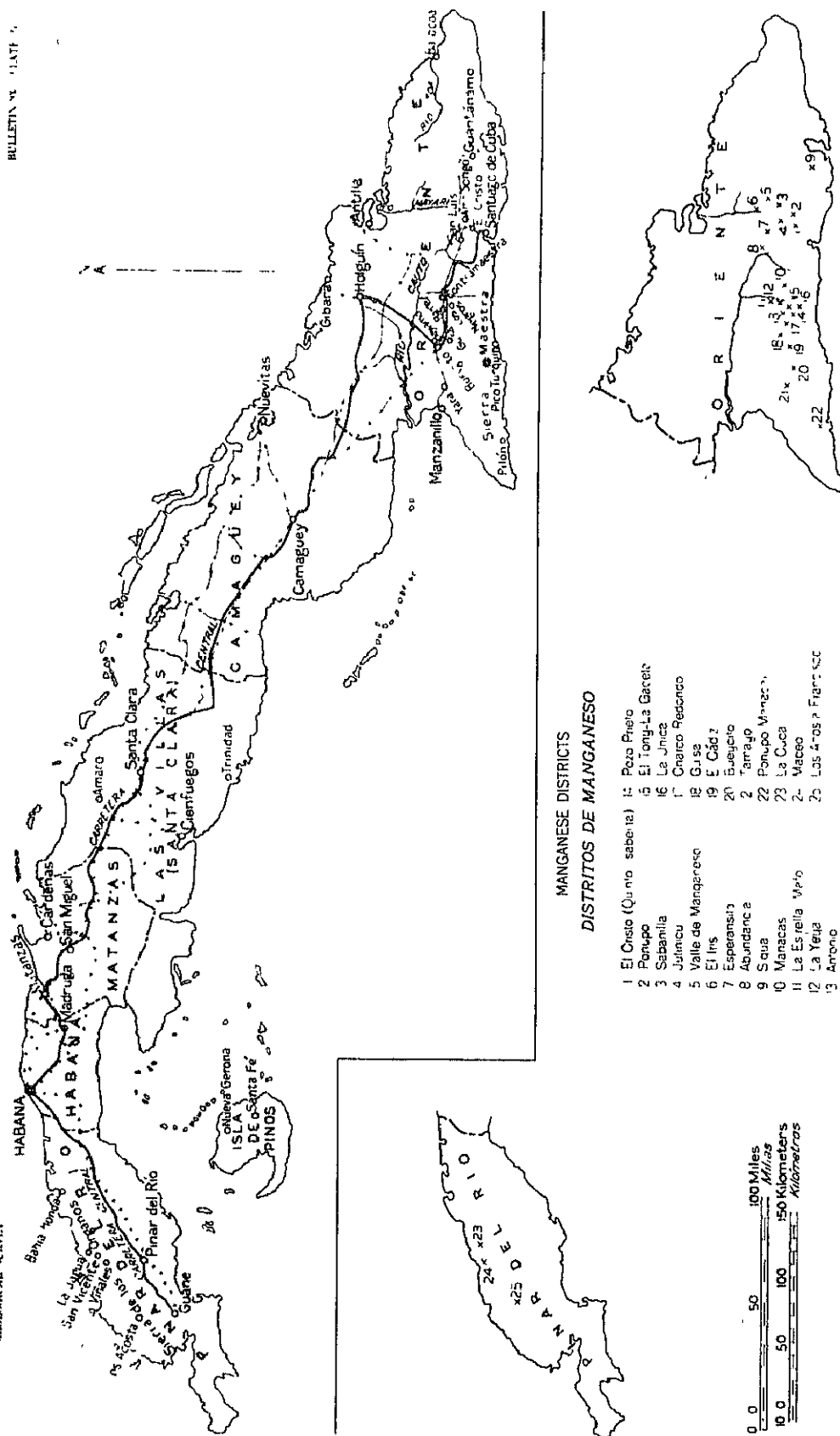


FIGURE VII-1. Index map of Cuba and location of Cuban manganese districts.

are between 786,000 and 2,590,000 long tons, could increase annual Cuban production by 100,000 tons of ore of 50-percent grade. Reserves appear adequate for maintaining production at this increased rate for at least 5 years, but output at this level for a longer period would depend on confirmation of the reserves listed in the inferred class and the finding of new deposits.

#### D. MEXICO (12)

Manganese deposits occur widely throughout Mexico; they have been reported from 335 locations in 20 of the 30 States and Territories of that country. Since 1942 Mexico has been a fairly substantial producer of manganese ore, an average of more than 50,000 tons a year.

The State of Baja California has been the leading producer in recent years and has the largest reserves for the future; 700,000 tons of ore are thought to be available there. Baja California is followed by: Chihuahua, 285,000 tons; Zacatecas, 230,000 tons; Durango, 70,000 tons; San Luis Potosi, 65,000 tons; Sonora, 28,000 tons; Coahuila, 27,000; and lesser amounts in 13 other States. Together these amount to about 1,500,000 metric tons.

The deposits of manganese in Mexico have been classified as of four main types: (1) Fissure deposits, which consist of manganese oxide and calcite in fissures in volcanic rocks and also of thin stringers of manganese oxides widely distributed throughout a basalt flow; (2) replacement deposits in silicified zones in fractured tuffaceous and volcanic rocks (tuff is a rock, usually bedded, consisting of fine fragments of volcanic ejecta cemented together; (3) replacement bodies in limestone adjacent to igneous intrusions; and (4) replacement deposits of manganese oxides in tuffs.

Most of the ore is found in a few large deposits, of which the Lucifer, near Santa Rosalia, Baja California, is the largest. The Gavilan deposit, in Baja California, and the Talamantes, in Chihuahua, are also in the large class. All these have reported reserves exceeding 125,000 metric tons. Several other deposits are of medium size (10,000 to 50,000 tons). Among these are: In Chihuahua, the Borregos, Casas Grandes, Zacate-Chino, and Organos deposits; in Coahuila, the Candela deposit; in San Luis Potosi, the Montana de Manganese deposit; and in Zacatecas, the Tinaja, Manganita, Abundancia, San Felipe, Tenango, and Negra deposits. The rest of the deposits in Mexico are much smaller.

The Lucifer deposit is in class (4) (above). Except for a few minor deposits nearby, it is the only deposit of its kind in Mexico. It has

been called "probably the best manganese mine in North America." The ore occurs in bedded tuffs and ranges in thickness from 1 to 6 meters, averaging 3 meters. Lenses of unreplaced tuff are scattered throughout the ore. The manganese content of the ore ranges from 37 to 57 percent, averaging 48 percent. The principal ore minerals are cryptomelane (a form of psilomelane) and pyrolusite. The deposit is mined underground by a rather inefficient system of intersecting drifts and crosscuts; pillars of ore are left behind that contain larger quantities of ore than those removed. The whole extent of the deposit is not yet determined but it is known to extend well beyond the present limits of exploration.

The deposits in the Talamantes area are of type (1). It (type 1) is the most common type found in Mexico. In this type of deposit the ore is mixed with country rock in fracture zones along fissures and faults. Black oxides of manganese are commonly so intimately mixed with calcite as to cause this usually colorless mineral to appear black. Calcite is not always present, however. The ore bodies are variable in form and size. They are usually found as lenses and shoots along fracture zones and range in length from less than 50 meters to several hundred meters and in width from a fraction of 1 centimeter to over 3 meters, averaging about 1 meter. The depth of the oxide zone below the surface ranges from 3 to over 100 meters. Although variable in grade, the ore usually runs between 25 and 35 percent manganese; sorting raises grade to 40 percent. Cryptomelane, hollandite, and ramsdellite are the principal ore minerals. The Talamantes area, including the dumps, has reserves of more than 125,000 tons.

A special type of fissure deposit is found in the Gavilan area, where a basalt flow some 23 meters thick has been thoroughly fractured and impregnated with innumerable veinlets of hard black oxides. The ore is high in  $MnO_2$  and reported to be of battery grade; the grade of the ore is, however, very low, running only 2 to 10 percent manganese. Because it breaks rather cleanly from the rock when crushed, the ore can be concentrated by jigging.

Of lesser importance in the classification are types (2) and (3). The Abundancia mine, in Zacatecas, is an example of the former. Here, shattered volcanic rocks have been subjected to replacement by silica and manganese oxides, along faults and fissures. Manganese minerals, such as braunite, pyrolusite, psilomelane, manganite, and others, are intimately mixed with silica, complicating beneficiation techniques. Run-of-mine ore from the Abundancia mine contains 35.3 to 52.0 percent manganese and 4.4 to 23.2 percent silica.

Table VIII-4. LOCATION, TYPE OF DEPOSIT AND RESERVES OF THE MORE IMPORTANT MEXICAN MANGANESE DEPOSITS

Name	Location			Type of deposit, remarks	Reserves	
	North latitude	West longitude	Direction and air-line distance from place named (in kilometers)		Metric tons	Percent of manganese
Lucifer mine	27°22'	112°25'	<u>BAJA CALIFORNIA</u> 17 northwest of Santa Rosalia. 20 each of Mulege	Replacement deposits in tufts	AA	45-50
Gavilan deposits	26°52'	111°52'		Numerous veinlets and stringers in basaltic rocks.		
Borregos area	31°10'	107°21'	<u>CHIHUAHUA</u> 15 southeast of Guzman.	Black calcite in fissures in rhyolite	A	30
Casas Grandes area	30°23'	107°59'	10 southwest of Nuevo Casas Grandes.	Black calcite veins in rhyolite	A	30
Zacate mine	28°10'	106°58'	20 south of Las Palomas	Fracture deposit in rhyolite	--	30
Chiro deposits	26°08'	106°06'	26 south of Las Palomas	Black calcite veins in rhyolite	A	30
Organos deposits	26°17'	104°55'	50 northeast of Saucillo	do	A	30
Talamantes manganese district.	26°53'	105°26'	20 each of Parral	Veins and replacement of matrix of fault breccia, in volcanic rocks	---	25

Name	Location			Type of deposit, remarks	Reserves	
	North latitude	West longitude	Direction and air-line distance from place named (in kilometers)		Metric tons	Percent of manganese
Candela deposits	26°48'	100°55'	<u>COAHUILA</u> 26 west of Candela	Veins and replacement deposits along igneous contacts with limestone. Contain calcite, fluorite, barite, galena, and some alabandite	1	40
Dinamita deposits	25°40'	103°40'	<u>DURANGO</u> 30 northwest of Torreon, Coahuila	Replacement deposits in massive limestone, around granite stock. Black calcite and manganese oxides. Similar to the Dinamita deposits	A	38
Sarnosa deposit	25°40'	103°40'	In the Dinamita area	do	A	45
Luz deposit	25°39'	103°39'	1 west of the Nena deposit	do	A	36
Picacho de La Candela deposits	25°25'	105°28'	30 east of Tepehuanes	Replacement of tuffs, fissure fillings, and coatings of manganese oxides on breccia fragments	A	30

Name	Location			Type of deposit, remarks	Reserves	
	North lati- tude	West longi- tude	Direction and air- line distance from place named (in kilometers)		Met- ric tons	Percent of man- ganese
Guadalupe de- posit	25°24'	105°28'	<u>DURANGO</u> Just south of the President Roosevelt de- posit	Replacement of tuff	A	30
Guadalupana de- posits	18°27'	100°7'	<u>MEXICO</u> 15 north of Arcelia, Guerrero	Chimneys in silicified frac- ture zones in tuffs.	A	40
Montana de Man- neso mine	23°20'	101°47'	<u>SAN LUIS POTOSI</u> 5 southwest of Santo Domingo	Manganese oxides and braunite with silica, in vein- lets and chim- ney like bodies that replace tuffs.	A	40
Illescas de- posits	23°9'	102°1'	12 southeast of Illescas	Probably similar to Montana de Manganese. Ore said to contain about 35 percent of manganese and 12 to 22 percent of silica.	A	35

Name	Location			Type of deposits, remarks	Reserves	
	North lati- tude	West longi- tude	Direction and air- line distance from place named (in kilometers)		Met- ric tons	Percent of man- ganese
Carr deposits.	31°15'	109°41'	<u>SONORA</u> 18 southwest of Agua Prieta	Replacement of thin beds of limestone, parallel to bedding. Princi- pally braunte Lenses along shear zone be- tween gneiss and schist.	A	35
Antillas de- posit	30°40'	110°58'	3 west of Mag- dalena		A	30
Tinaja deposit	23°29'	102°39'	<u>ZACATECAS</u> 14 south of Canitas	Chirneylike bodies in silic- ified rhyolitic rocks. Lenses in silic- ified rhyolite tuffs.	A	20
Manganita de- posit	23°37'	102°20'	35 east of Canitas		A	40
Tinajita de- posit	23°37'	102°20'	Just east of Humo de Oro claim	Similar to Maga- nita. One cut 15 meters in diameter ex- poses vein 2 meters wide.	A	40



Name	Location			Types of deposits, remarks	Reserves	
	North lati- tude	West longi- tude	Direction and air- line distance from place named (in kilometers)		Metric tons	Percent of man- ganese
Abundancia mine	23°37'	102°12'	<u>ZACATECAS</u> Northeast of Villa de Cos.	Lenses, Chum- neys, and vein- lets in partly silicified tuffa- ceous clays, which in places are replaced along bedding planes.		
Tenango de- posits	23°31'	102°17'	10 northeast of the San Felipe de Jesus de- posit	Replacement bodies along fissures and nearly flat bedding planes, in partly si- licified tuffs.	A	40
Negra deposit	23°10'	102°54'	7 southwest of Fresnillo	Siliceous re- placement zone in rhyolitic rocks.	A	40
					A	30

/1 In the column "Reserves, Metric tons" AA represents large-size deposits and A represents medium-size deposits.

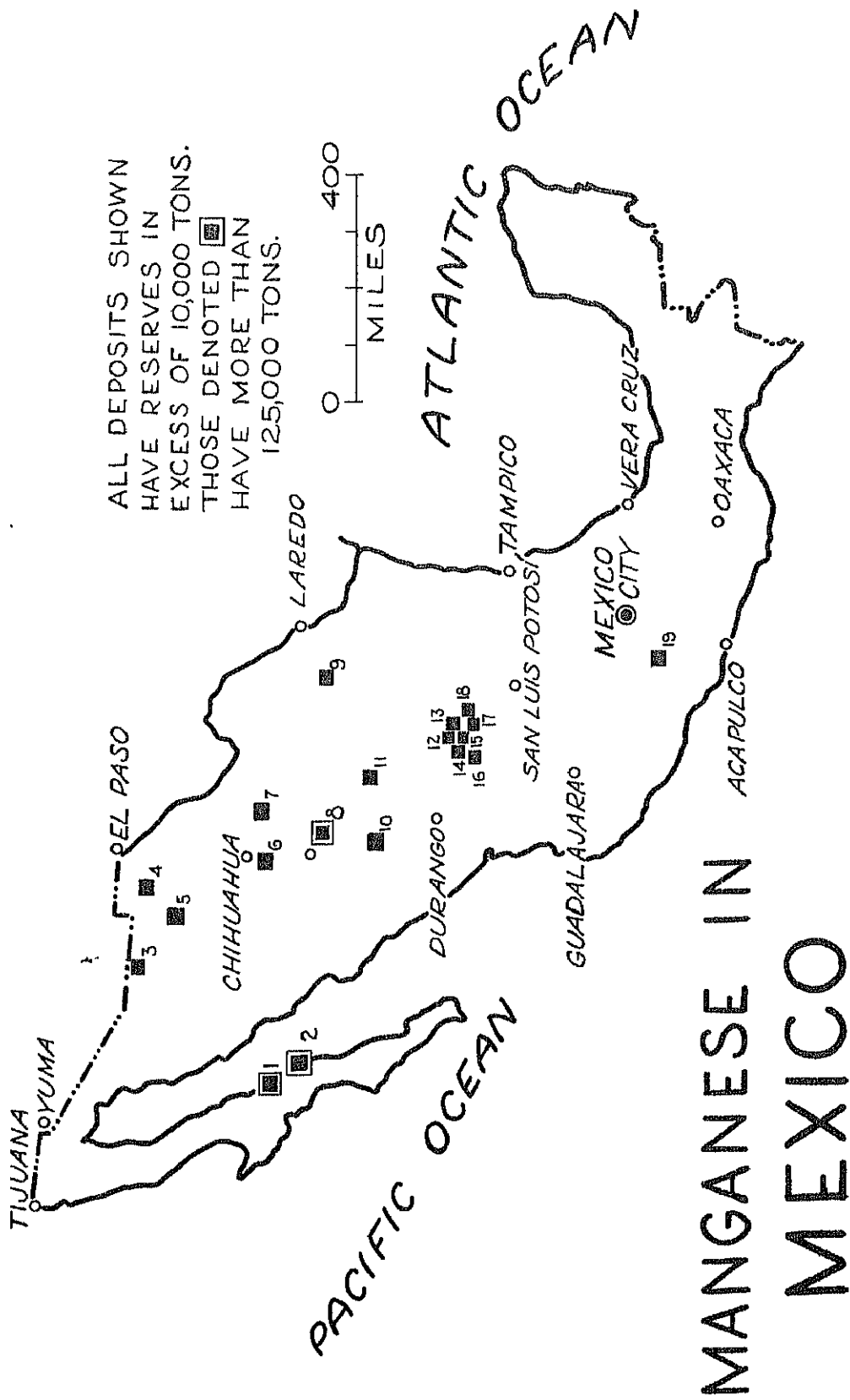
# LIST OF MEXICAN MANGANESE DEPOSITS TO ACCOMPANY MAP

## BY SEQUENCE:

1. Lucifer mine
2. Gavilan deposits
3. Carr deposits
4. Borregos area
5. Casa Grandes area
6. Zacate mine
7. Organos deposits
8. Talamantes district
9. Candela deposits
10. Picacho de La Candela deposits
11. Dinamita deposits
12. Manganita deposit
13. Abundancia mine
14. Tinaja deposit
15. Tenango deposit
16. Negra deposit
17. Illescas deposits
18. Montana de Manganeso mine
19. Guadalupana deposits

## BY STATES:

- Baja California
1. Lucifer mine
  2. Gavilan deposits
- Chihuahua
4. Borregos area
  5. Casa Grandes area
  6. Zacate mine
  7. Organos deposits
  8. Talamantes district
- Coahuila
9. Candela deposits
- Durango
10. Picacho de La Candela deposits
  11. Dinamita deposits
- Mexico
19. Guadalupana deposits
- San Luis Potosi
17. Illescas deposits
  18. Montana de Manganeso mine
- Sonora
3. Carr deposits
- Zacatecas
12. Manganita deposit
  13. Abundancia mine
  14. Tinaja deposit
  15. Tenango deposit
  16. Negra deposit



Similarly, samples from the Montana de Manganeso mine range from 35.1 to 50.1 percent manganese and 11.6 to 37.6 percent silica.

Last, and probably least in importance, are replacement bodies in limestone adjacent to intrusive bodies of granite. Ore is found in both recrystallized and unmetamorphosed limestone. The ore minerals are generally manganese oxides, with or without interstitial calcite. Generally manganese constitutes less than 25 percent of the rock, necessitating careful sorting. Most deposits of this type are relatively small, the inferred ore amounting in general to less than 2,000 tons. Only three deposits, the Sarnosa and the Luz in Durango and the Milagro in Coahuila, have reserves of 10,000 tons or more each.

Table VIII-4 gives the names of and general information concerning large (over 125,000 tons) and medium-size (10,000-to 125,000 ton) deposits. For a detailed list of all 335 Mexican deposits, the reader is referred to table 17, pp. 291-312, in the reference cited above. (footnote 12)

#### E. PANAMA

Southern Panama has numerous deposits and occurrences of manganese, some of which have produced significant tonnages of plus-50-percent product. Jungle covers much of the area, making prospecting difficult. Exports were principally psilomelane, with some braunite and pyrolusite, (13) which occurred as irregular lenses of varying size in decomposed shale. During World War I, the second period of significant production in Panama, the mine product was hand-cobbed, washed, and screened to a reported grade of 57.8 percent manganese, 4.2 percent silica, and 0.06 percent phosphorus.

A private report on the properties of the Panama Exploration Syndicate (dated July 1, 1923), by Orrin P. Peterson of Marysville, Calif., in brief, gives the following data and personal estimates on manganese showings in Panama:

1. La Matilde manganese property near Ponuga, Veraguas: Reserves might be developed to the extent of several million tons of 20-percent manganese material. Probably one-half of this tonnage could be sorted out by hand as 30-percent manganese product. Suitable concentration methods might be developed to produce a 35-percent or better product from the run-of-mine material; but, as of the date of the report, no such method was available. Silica appears to be the principle impurity.

2. Nuestros Amo manganese property, 12 km. southeasterly from Santiago: Less than 50 tons in sight at the time of the examination, with the possibility that exploration might develop several thousand tons. The manganese-bearing material occurs as fragments and nodules in basic igneous rock. Samples composed of all visible material assayed 50.92 percent manganese, 0.60 percent iron, and 0.25 percent copper.

3. Harriet manganese property, 2 or 3 miles from tidewater on Bahia Honda, Veraguas: Some 400 tons of float estimated at the time of the examination with the probability that 1,000 tons could be developed. Grade such that a 40-percent product could be produced. Deposits occur as veins traversing a basic igneous formation resembling serpentine.

The Matilde deposit is now owned by a Horacio Velarde who is associated with a William R. Wright of Ancon, Canal Zone, on matters of promotion.

In 1945 it was reported (14) that a concession to mine eight manganese deposits in the Porto Bello district, Colon Province, had been granted to Dr. R. R. Aleman as representative of S. St. Clair, Washington, D. C. Further details of the concession contract were published (15) in 1946.

#### F. PUERTO RICO

From 1916 through 1938, Puerto Rico was a small producer of battery-grade manganese ore, the entire output coming from the Atlantic Ore Co. mine, about 3 miles from Juana Diaz. Shipping-grade was classified as 48.51-percent manganese content. The ore, consisting of psilomeland and pyrolusite, was found in small, irregular lenses near the surface of a crystalline limestone. It is not clear whether production stopped because of depletion, as Meyerhoff (16) had reported only a few years earlier that investigations had doubled the area of known deposits.

#### G. ISLAND OF ST. MARTIN, WEST INDIES

Shortly after 1900, two shipments of manganese ore were made to the New York market from a deposit at Cay Bay, near Philipsburg, in the Dutch part of the island. The material is reported (17) to have analyzed 45 percent manganese, 5 percent iron, 0.09 percent phosphorus, and 9.5 percent silica. Another area, 2 miles away, was

reported to show higher manganese, with lower iron and silica and somewhat higher phosphorus content.

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## IX. SOUTH AMERICA



## CHAPTER IX. SOUTH AMERICA

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## IX. SOUTH AMERICA

### A. ARGENTINA

There are no substantial producers of manganese in Argentina. Small output, however (up to a few thousand tons per year), is obtained from numerous deposits in an area some 20 miles wide extending 50 or more miles south from Ambargasta in the southwest part of the Province of Santiago del Estero to Dean Funes, in the Province of Cordoba, 80 miles north of Cordoba.

The deposits, principally psilomelane but with some pyrolusite and manganite, occur as irregular masses and veins, from 1 foot to 6 or more feet wide, in bedded formations.

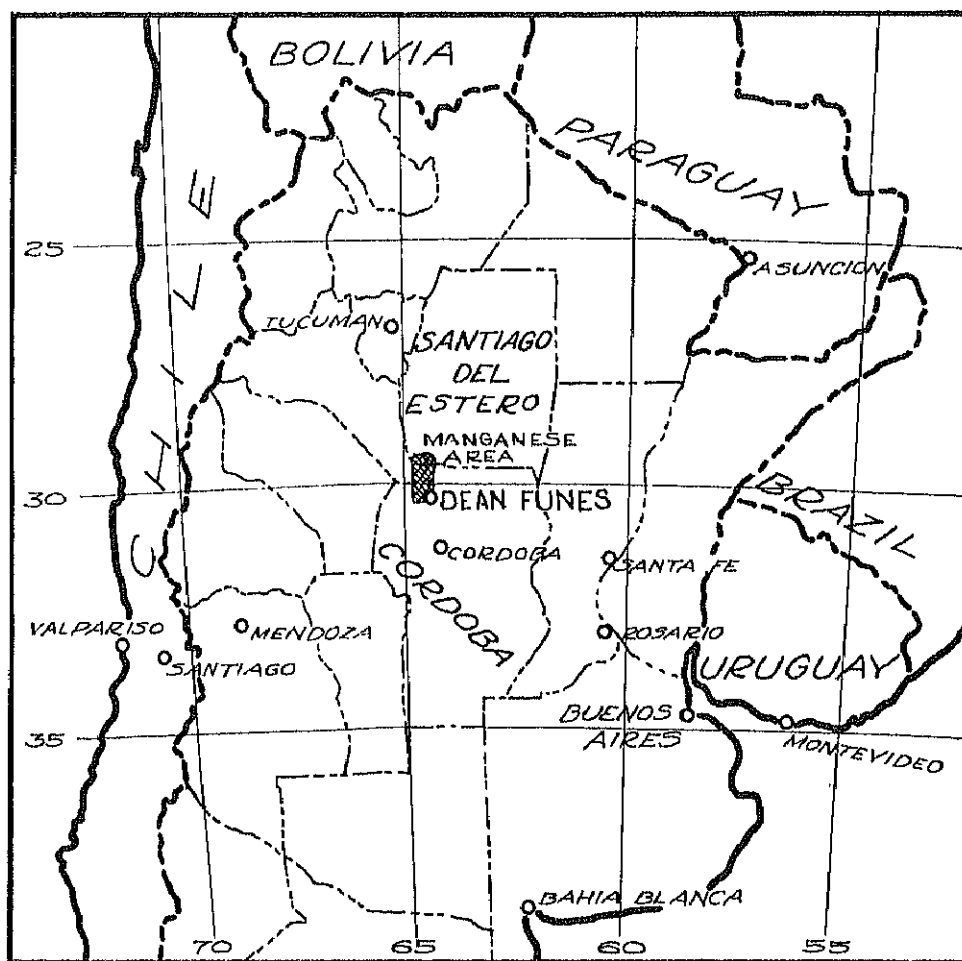


FIGURE IX-1. Manganese area in Argentina

Mining is by shallow open pits with the product hand-sorted to a grade of 55 to 60 percent  $MnO_2$ . A dozen or so mining locations have been noted, (1) of which Aguada del Monte in Cordoba and the Lus Ancoches area, 12 miles to the north in Santiago del Estero Province, are the most important.

In 1928, a deposit was reported (2) on the Bolivian border, some 10 kilometers west of La Quiaca in relatively inaccessible country. The bed, dipping at  $20^\circ$ , was stated to be 7 meters thick and traceable for  $1/2$  kilometer. Analysis was given at 52.5 percent manganese and 3.9 percent iron.

## B. BOLIVIA

To date, no manganese deposits have been reported (3) in Bolivia, although it is understood that the eastern part of the country, which borders on Mato Grosso province, Brazil, may be favorable geologically and has not yet been explored to any degree.

## C. BRAZIL

Manganese deposits of commercial size are known in four locations in Brazil, the States of Minas Geraes, Bahia, and Mato Grosso and the Territory of Amapa. The first of these, Minas Geraes, is the only major producer to date. The Bahia deposits are so small as to be insignificant. Mato Grosso and Amapa both contain extensive reserves that are just now in the initial stages of development.

### Minas Geraes District

There are two mining areas in Minas Geraes, one at Queluz (Lafayette), the other at Miguel Burnier (Burnier). There are also two district modes of geologic occurrence. In the first, ore occurs throughout a granite-gneiss-schist complex. In the second, ore is found in the metamorphosed sediments overlying the complex. The former is recognized at Queluz, the latter at Miguel Burnier and nearby Ouro Preto. The average distance from these places to Rio de Janeiro is about 297 miles by rail.

The Queluz (Lafayette) ore bodies are scattered throughout the complex with no definite scheme. They are lenses that are residual concentrations of a rock originally made up of  $MnCO_3$  and silicates. The wall rock, which is the source rock, is characterized by a high percentage of garnet. The principal constituents are rhodochrosite, spessartite (Mn garnet), rhodonite, and tephroite (Mn-olivine) in



order of abundance. The original rock, probably an impure manganese carbonate rock, was altered to its present form by regional metamorphism. Weathering in the zone of oxidation has formed ore which is usually amorphous (psilomelane and wad) with some pyrolusite (pollanite). The chief reagent was meteoric water. (4) Field and microscopic evidence indicates that rhodochrosite, tephroite, and rhodonite were converted simultaneously to manganese oxides, with garnet remaining embedded in a matrix of the oxide. In some places, even the garnet has been converted to oxide. The largest mine in the Queluz district is the Morro da Mina, whose reserves were estimated in 1938 (5) at 5,000,000 tons.

In the Miguel Burnier district, the occurrence is somewhat different. The ore is found as fairly definite beds and lenses in a sedimentary series. They are associated with the Itabira iron formation. The principal bed is 2 to 3 miles in length and reaches a thickness of over 6 feet. It strikes east-west and dips steeply to both sides. Because of the structure and thinness of the beds, mining has to be done underground. The ore is largely a fine-grained mixture of psilomelane and pyrolusite, averaging 50 percent Mn, 1 percent  $\text{SiO}_2$ , and 0.03 to 0.05 percent P. Just how these ores originated is a question. Harder and Chamberlain (6) have interpreted them as original sedimentary deposits; the source may have been pods of the Queluz type. Scott, (7) on the other hand, considered them to be residual products of leaching of some other, earlier-formed, rock. Singewald and Miller (8) pointed out that the ore is coextensive with limestone lenses in the sedimentary series and inferred that it is probably a product of replacement of that limestone. They point out, as supporting evidence, that the country rock is also very much altered, particularly in the hanging-wall portions.

Teixeira (9) states that the production capacity of the Minas Geraes mines is about 20,000 tons a month and that it could be doubled or trebled, if necessary. He estimated reserves at 4,000,000 tons.

#### Bahia District

This district is 30 miles inland from the port of Bahia. The ores occur in decomposed materials derived from the weathering of a schist. (10) The ore is mainly psilomelane, occurring as lumps and masses in clay and soft earth. An average analysis is Mn 43 to 49 percent,  $\text{SiO}_2$  3 to 4 percent, P 0.016 percent, moisture 2 to 3 percent.

#### Mato Grosso

The deposits at Morro du Urucum are among the largest in the

world. Reserves are estimated at 20 to 30 million tons. (11) Morro du Urucum is a mesa about 25 km. south of Corumba, near the Bolivian border. The deposits are 2,000 miles from the Brazilian coast at Santos. For this reason, they have so far been unable to compete effectively. What ore has been mined has been shipped down the Paraguay River to Rosario.

All of the commercial manganese deposits are found within the Band' Alta formation, which is defined as a series of banded hematite beds, associated with subordinate beds of manganese oxide, siltstone, sandstone, and jasper (12). Its greatest measured thickness in the Morro du Urucum is slightly over 300 meters. It consists of massive beds averaging about 1.5 meters in thickness and ranging up to more than 6 meters. Most of the beds consist of hematitic rock which runs about 55 percent iron and 20 percent silica. Dorr estimated over a billion tons of hematite in this formation.

The reserve picture (14) is summarized in table IX-1.

Table IX-1. RESERVES AND GRADE OF MANGANESE ORES,  
MORRO DU URUCUM

	Metric tons	Wt'd average grade, %	
		Mn	Fe
<u>Bed I</u>			
Measured ore	3,120,000		
Indicated ore	8,400,000		
Inferred ore	12,650,000		
	<u>24,170,000</u>	45.0	11.2
<u>Bed II</u>			
Measured ore	1,300,000		
Indicated ore	3,350,000		
Inferred ore	4,850,000		
	<u>9,500,000</u>	47.2	11.0
Total measured ore	4,420,000		
Total indicated ore	11,750,000		
Total inferred ore	17,500,000		
	<u>33,670,000</u>	45.6	11.1

At or near the base of the Band' Alta formation is a persistent bed of the manganese oxide, cryptomelane (a form of psilomelane), which varies in thickness from 20 cm. to nearly 6 meters. From 30 to 45 meters higher is a second, less-widespread bed of the same material, ranging up to 2.2 meters in thickness. These beds are characteristically dull-black to dark-gray on the outcrop, although fresh surfaces have a more metallic luster. The mangiferous beds contain nodules of material similar to that surrounding them.

Dorr (13) concludes that the Band' Alta manganese ores are original sedimentary deposits, but he does not attempt to explain how the mangiferous and ferruginous components became so neatly separated. Nor is there any inference as to the ultimate source, although it is held that regional studies may disclose it.

#### Amapa (15)

Impressive outcrops of manganese ores were discovered in Amapa, about 240 km. from the Amazon (see index map) in 1941, and since then 28 separate deposits have become known in an area 7 km. by 1 km., now known as the Serra do Navio district. The ore was probably derived from a manganese silicate-carbonate-sulfide rock by weathering. The main mineral is cryptomelane (psilomelane), and the presence of pyrolusite, while reported, is doubtful. The grade is high, averaging about 50 percent Mn. Reserve estimates run as follows:

	<u>Tons</u>
Visible ore	585,000
Probable ore	2,700,000
Possible ore	4,000,000
	<u>7,285,000</u>
Detrital ore	500,000
Total	7,785,000

As of early 1951, a report (16) on explorations at Amapa indicate that reserves are currently of the order of 25,000,000 tons.

The manganese deposit, it has been reported, (17) will be developed and operated jointly by Bethlehem Steel Corp. and Industria e Comercio de Minerios, South America (ICOMI), of Belo Horizonte, Brazilian concessionaire.

The concession, first granted late in 1947, covers 2,500 hectares (about 6,200 acres) of land and grants (18) exclusive mining rights for 50 years plus the right to export up to 500,000 tons of ore annually, which, it is understood, Bethlehem Steel Corp. is willing to purchase on guarantee that it will receive 49 percent of the output. (19)



FIGURE IX-2. Morro do Urucum manganese deposit, Mato Grasso, Brazil

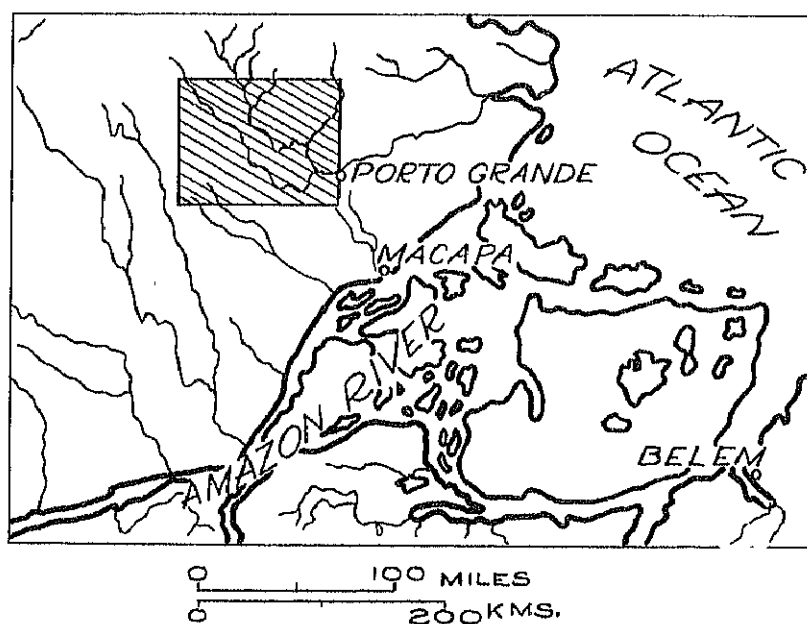


FIGURE IX-3. Manganese deposits of the Serra do Navio district, territory of Amapá, Brazil

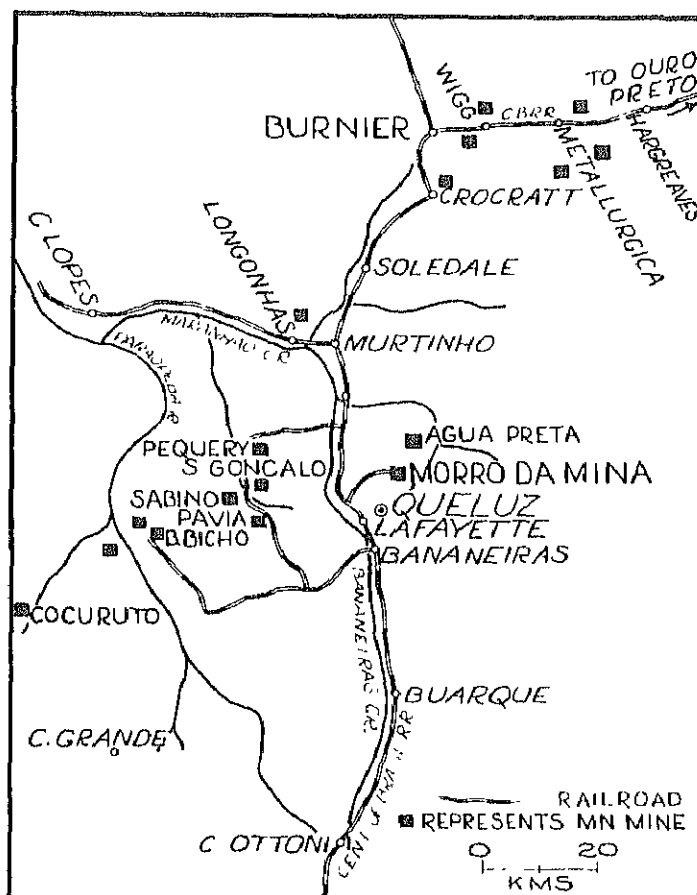
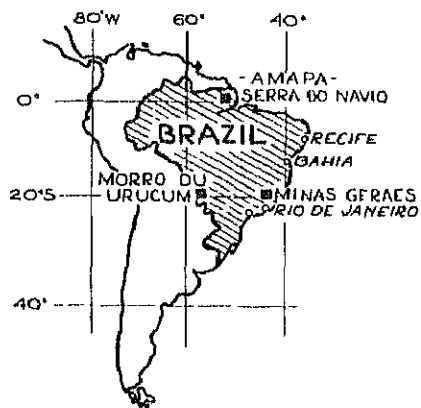


FIGURE IX-4. Manganese deposits of the Lafayette and Miguel Burnier districts. Minas Geraes, Brazil



The concession agreement is understood further to require that the company build a railroad before the end of 1955 from the mines to the Amazon River (132 miles from mines to the port of Macapa) should the reserves in the deposits exceed 10,000,000 tons. Application to the International (World) Bank for a loan of \$35,000,000 is reported to have been guaranteed by the Brazilian Treasury when Bethlehem Steel Corp. undertook to purchase the full amount of exports so as to open a market for the output.

Although a token shipment of 100 tons of Amapa ore has been sent to the Volta Redonda Steel Works, it is unlikely that substantial output will be achieved before 1954 because of the extensive development and road construction that will be needed.

#### D. BRITISH GUIANA

The Colonial Geological Survey is reported (21) to have examined a manganese deposit at Saxicalli, on the lower Essequibo River. The deposit, of considerable size, assays 10 to 32 percent manganese content, which is considered too low for commercial exploitation without concentration.

#### E. CHILE

Chilean manganese mines have been strictly marginal operations since their beginnings, with the exception of 20 years' active production (1885-1905), when they produced over half a million tons of exports, mostly to the United States. Both the first and second world wars gave impetus to production of manganese in Chile, with shipments of over 100,000 tons in 1943; otherwise, production has been negligible if not nil since soon after the turn of the century. There are, however, reasonably large reserves that are not far removed from shipping lanes. For this reason, Chile remains a good potential source of manganese ore.

Manganese ores occur in the Huasco and Carrizal districts at Atacama (see map for locations); the Los Chorros, Las Canas, La Grana, Arrayan, and Corral Quemada districts of Coquimbo; and the Punita district to the south of Santiago, near San Filip (north of San Felipe), near Chanaral and north of Antofagasta. Of these, the Atacama and Coquimbo deposits are the most important. Brief descriptions of these follow.

Harder (22) describes three types of geologic occurrence: (1) Ores occurring interbedded with jasper and chert in a limestone-chert formation; (2) ores occurring interbedded with red sandstone, shale, and limestone, which in turn are interbedded with massive volcanic flows; and (3) ores occurring as veins in volcanic flows.

To the first type belong the ores of Atacama. To the second, all the Coquimbo deposits except those at Los Chorros. The latter, along with those ores at Aculeo, belong in class three.

#### Atacama

The deposits are in the Coast Range between Huasco and Carrizal, about 350 miles north of Valparaiso. They trend in a north-south belt, striking in the same direction in the northern part of the belt. Here, they are nearly vertical, dipping  $60^{\circ}$  to  $70^{\circ}$  east, or even west. Ore is enclosed by interbedded gray chert and limestone and gray shale. The manganese beds range from less than 1 foot to 4 or 5 feet thick and are enclosed immediately by jasper, which is succeeded outward by red chert. The ore is dense, hard, black psilomelane that has a conchoidal fracture (glass breaks with a conchoidal fracture). In the southern part of the belt, the ore beds strike northeast - southwest and dip about  $45^{\circ}$  northwest. The general mode of occurrence is similar to that farther north, except that the ore is mostly bluish-black braunite. The mines in this district have been idle since the start of the present century. (23)

#### Coquimbo

All the various districts in Coquimbo Province are situated within a relatively small area about 230 miles north of Valparaiso. They are found in the west foothills of the Andes Mountains. Ore occurs along a 40-mile line from northeast of Ovalle to east of La Serena. Manganese-bearing sediments are interbedded with massive volcanic flows, sandstones, shales, conglomerates and limestones. The ore beds conform structurally with the enclosing rocks and are closely associated with the limestones. The thickness varies between 1 to 3 feet. Dips generally range between  $20^{\circ}$  and  $30^{\circ}$ . Pyrolusite is the main ore mineral; it is blue to black, fine-grained to granular, compact but soft.

Analyses of ores from the various districts in Coquimbo Province are shown in table IX-2 on the following page. (24)

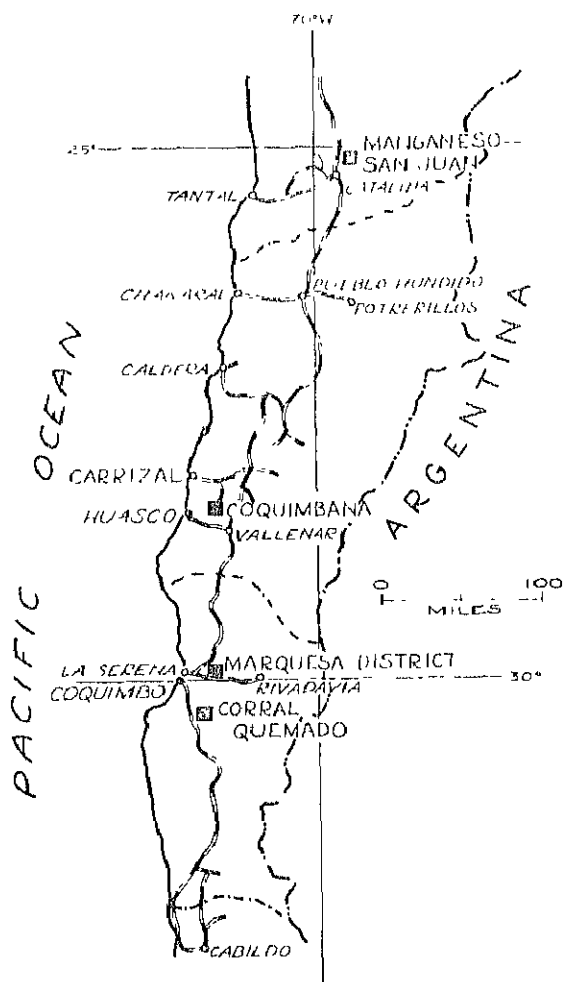


FIGURE IX-5. Manganese deposits of Chile





Table IX-2. ANALYSES OF ORES FROM  
COQUIMBO PROVINCE, CHILE

	Corral Quemada	Mina Alta, Las Canas	Mina Potosi, Las Canas	Mina Estrella, La Liga
Mn	50.0%	40.31%	52.85%	49.54%
Fe	.78	3.38	1.09	1.29
SiO <sub>2</sub>	9.43	11.20	7.74	5.00
P	.013	.022	.007	.10
Combined H <sub>2</sub> O	1.18	1.15	.9	1.00

Since most of the beds are steep-dipping, mining, when carried to any depth, is by underground methods, with access generally through side-hill adits or tunnels, although shafts and inclines are sunk when required. Mining is by stoping above and below the adit levels, with pillars and waste rock fill left for support as needed. Mining is not well-organized in many instances, and costs are increased further because 2 to 3 tons of ore (or rock) in place must be mined to sort out each ton or exportable product, usually of a grade containing 46 percent manganese.

Reserves of 35-percent manganese ore suitable for hand-sorting to export grades have been estimated (25) by the Chilean Bureau of Mines at 300,000 tons, from which about 100,000 tons of export product could be obtained. In addition, the estimate includes some 1,200,000 tons of 30-percent manganese material suitable for concentrating.

To date, all Chilean ore has been hand-sorted, usually at or in the mines. Water is scarce in the mining areas. Attention is being given, however, to the possibility of deep-seated water sources and to methods of beneficiation, such as the sink-float process, that do not use much water. Given favorable purchase schedules, both as to price and grade, Benitez (26) concluded that 40,000 tons of 46-percent manganese ore might be produced in Chile per year.

#### F. COLOMBIA

No manganese deposits of any significance are known in Colombia. Two prospects are reported (27) in the Department of Caldas, some 150 kilometers west of Bogota, from which small amounts of hand-sorted, 40-percent manganese product might be obtained at high

ane and pyrolusite are the evident minerals, in the ratio of

Lenses up to about 100 tons in size are distributed erratically in siliceous and clayey shales. A few hundred tons were known before 1943.

## G. ECUADOR

A small area of bedded oxides near San Antonio, Province of Cotacachi, 28 miles from Quito, was worked (28) during 1918. Shipments apparently totaled 129 tons. Average analysis was 46.36 percent Mn, 1.55 Fe, 0.02 Cu, 0.14 P, and 6.44 percent  $\text{SiO}_2$ . Conditions are understood to favor cheap mining.

Stov, in his tabulation of world manganese ores, lists the reserves for Ecuador at 120 million tons of 54-percent manganese content. He makes the qualifying statement that Ecuador could become an important manganese source if these reserves are proved. He undoubtedly refers to the reported (29) deposits discovered in 1929 at Sacachispa, near El Oro Province, western Ecuador, where a number of holes, drilled to a depth of 28 feet without reaching the bottom of the deposit, gave a composite analysis of 54.65 percent Mn, 0.61  $\text{SiO}_2$ , 0.08 P, and 1.52 percent Fe. In 1937, a 30-year concession in this area was granted by the Government on 16 claims estimated by the concessionaires to contain 75 million tons, some of which would run 54 percent manganese. Some authorities are reported (30) to have considered these deposits of no commercial value, possibly in view of their unfavorable geographic location. Since no recent reference to these deposits has been found in geologic literature, it is probable that their extent and economic status is still questionable.

Widdensburg (31) notes both the Passaje and San Antonio deposits and lists them in his world review as large potential sources but adds nothing new of conclusive data.

## H. HAITI

Manganese ore is not produced in Haiti, and indicated reserves are small as to have little interest.

On the basis of field work done in 1941-42, the Federal Geological Survey reports (81) that three areas are worth further study. These are the Morne area in the northwest, the area north and north-west of the Cap-Haitien in the east part of the southern peninsula, and the borders of the Cap de la Hotte in the western part of the southern peninsula.

The manganese material is mainly oxides. Indicated reserves are some 6,000 tons of probable ore carrying 40 percent manganese and 33,750 tons of high-silica material averaging 20 to 25 percent manganese.

## I. PARAGUAY

Paraguay has no commercial deposit of manganese, although an occurrence of thin veinlets of pyrolusite in an extensive flat-lying hard, siliceous sandstone near Embocada, some 40 miles northeast of Asuncion, was explored unsuccessfully. (33)

## J. PERU

The Lampa Mining Co. was reported (34) to have produced small tonnages of manganese ore, before the last war from operations near Lampa, Puno Province.

Occurrences of manganese minerals in Usquil district and in the Paita y La Oroya area have been reported (35) as of little economic value.

## K. URUGUAY

Uruguay has large, low-grade, manganiferous deposits at Cerro Papagay and Cerro Iman in the Department of Rivera, some 12 miles south-east of Corrales. Neither of these is considered economic or desirable for direct shipment because of the high iron and silica content. Some alumina, lime, and magnesium mineral are also present. These two deposits are suitable for open-pit mining. They are 15 miles apart and stand out as hills above the pampa but are 57 miles from the nearest railroad station and are served only by dirt roads. Published estimates (36) of reserves are of the order of 80 million tons.

At Cerro Papagay, 14 samples from the best part of the deposit are reported (37) to have averaged 20.8 percent Mn, 32.2 percent Fe, and 9.4 percent  $\text{SiO}_2$ . Assays at Cerro Iman ran lower in manganese and higher in iron and silica. Both deposits have been explored to some extent by trenches and adits. The manganese beds have intercalations of clay and feldspathic rock; in one place an adit hit 18 seams of clay totaling 70 feet in thickness and 19 manganese beds totaling 108 feet.

Manganese occurrences are common throughout Uruguay. Small lenses of pyrolusite have been worked in schistose limestones near the Valencia lead mine, 7 miles from Minas in Lavalleja. Grade and tonnage are both too low for the deposits to be of commercial interest. An occurrence of several narrow veins of manganese has also been reported near Arroyo Grande 100 miles northwest of Montevideo.

Following World War I, small stringers of manganese were worked (38) at Pantanoso, near Montevideo. Recently, some publicity has been given (38) to vein deposits in schist formations at Carraseo, also near Montivideo.

To date, Uruguay has produced only a few small shipments of manganese ore.

#### L. VENEZUELA

Press reports (40) have mentioned the discovery of manganese deposits near the Orinoco Delta. Details were lacking.

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## X. ASIA



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## X. ASIA

### A. CHINA

For a country of its size, the manganese resources of China are not large; perhaps this is because much of the western area has not been prospected thoroughly. Known reserves, given by the Federal Bureau of Mines, (1) have been estimated at some 29 million tons of 20 to 50 percent  $\text{MnO}_2$  content. Over 18 million tons of this largely low-grade primary material are in Kwantung Province, southeast China. The best-grade ore and largest production is from Kwangsi Province, southwest China, where reserves are estimated at 3,638,000 tons of 47 to 50 percent  $\text{MnO}_2$  content. Other producing areas, in order, are Hunan, Kwantung, Liaoning, and Kiangsi Provinces. Total production, usually some 20 to 30 thousand tons per year, has, at times, reached 70 thousand tons. A large portion of the production is exported as the domestic steel industry has small requirements.

The best deposit in Kwangsi Province is thought to be Shanli-hsu, at Wu-hsuan, with reserves of 1,638,000 tons of 50 percent  $\text{MnO}_2$  content. The Mu-kuei deposit at Kuei-ping, with 2,000,000 tons estimated reserve of 47 percent  $\text{MnO}_2$  content, is considered capable of producing 100,000 tons per year compared with 20,000 for Shan-li-hsu.

The Chung-pu-chia deposit in Kiangsi Province is the largest in southeast China. Reserves here are over 3 million tons of 38 to 52 percent  $\text{MnO}_2$  content while the Shan-wu-tu deposit in adjoining Hunan Province contains about half as much tonnage of like grade.

Details of the numerous manganese deposits in China may be found in the reference cited.

### B. FORMOSA

Manganese deposits estimated at over 400,000 tons were reported (2) discovered in 1932 near Suwe, on the east coast of the island.

### C. INDIA

For many years the world's second leading producer of manganese ores, India has dropped in recent years owing to Government disorganization and lack of railroad facilities. There is, however, plenty of good manganese ore in India -- at least 20 years' reserve in the

Central Provinces at present rates of consumption. (3) Harder (4) lists 35 separate occurrences of ore; of these, only 17 had produced at the time of writing, and but 10 of those were of first-rank importance.

Fermor (5) classified the Indian ores as being of three types: (a) Gondite; (b) kodurite; and (c) "lateritoid" (like laterite, or residual). Of these, the first is by far the most common and important.

Gondite: Metamorphosed sediments of probable Archean age. The sediments as deposited were partly mechanical (sands and clays) and partly chemical (Mn oxides). Regional metamorphism has formed the rock types seen today. These rocks are characterized by the presence of manganese silicates like spessartite (garnet) and rhodonite.

The ore is an integral part of the rock mass, and the two grade into each other irregularly. Most of the ore resulted from the ancient metamorphism mentioned above, although some of it consists of enriched portions that have resulted from weathering of the metamorphic ores. The ore bodies are lenticular masses and bands in the metamorphic rocks. Generally they conform to the structure pattern of the country rocks.

This type of deposit is developed in Balaghat, Bhandara, Chhindwara and Nagpur in the Central Provinces (see map for locations), Shabua in Central India, Panch Mahals in Bombay and Ghanpur State in Bihar and Orissa.

The Balaghat deposit is 1 and 3/4 miles long; another group of deposits in the Balaghat district is exposed more or less continuously for 6 miles. The Manegaon deposit in the Nagpur district is 1.5 miles long. The Nagpur-Balaghat ores are mostly mixed psilomelane and bruante, in beds 40 to 50 feet thick.

An additional occurrence related to the gondite-type deposits is found in the Nagpur and Chhindwara districts. Ore occurs as lines of nodules or as beds in crystalline limestone. These deposits are not very good economically, however, and can be worked only on a marginal basis (that is, when conditions, particularly prices, permit).

Kodurite: These are typically developed in the Vizagapatam district on the east coast. They are closely associated with Archean crystalline rocks. The kodurite rocks look igneous (that is, crystallized from a molten state) and were first thought to be such. The

high manganese content opened that interpretation to question, however, and later investigators concluded that the rocks are probably hybrids which originated from assimilation of manganese bodies and rocks of the gondite type by acid magma. ("Magma" is defined as the molten mass from which igneous rocks later crystallize. "Acid," as pointed out above, means having a high silica content.)

Manganese silicates abound in the unaltered rock. Where altered by the oxidizing effects of weathering, the rocks have been turned into ores that are mainly psilomelane, with subordinate braunite, pyrolusite, and other minerals. The ores run around 40 percent Mn, and a good part of them are classified as ferruginous manganese ores (less than 40 percent manganese).

Because of their origin, the ore bodies are irregular in shape and size. The largest of them, at Garbham, is 1,600 feet long and 167 feet thick at the thickest point, of which about 100 feet is ore.

Lateritoid: Occur as cappings on outcrops of ancient metamorphosed sediments of the gondite type. The ores have resulted from weathering at or very near the surface, and as such are residual. They are cavernous, pisolitic, and earthy and intimately mixed with iron ores. There is a complete gradation from Mn ore through ferruginous Mn ores and manganiferous Fe ores to Fe ores. The manganese ore minerals are pyrolusite, psilomelane, and wad - the hard, crystalline minerals are indeed rare. The ore is of very poor quality. Examples are found in the Sandur Hills in Madras and in Chitaldrug, Shimoga and Tumkur in Mysore.

It would be well to describe in somewhat more detail one district in each of the three types noted. By far the most important is the "gondite" type. The three leading producing districts (Balaghat, Nagpur and Bhandara) are gondite deposits. They are, incidentally, all in the Central Provinces.

#### Balaghat, Bhandara, and Nagpur Districts

These are about half-way between Bombay and Calcutta and all lie in an area 120 miles east-west by 50 miles north-south. The deposits were originally laid down as sediments, and regional metamorphism has formed the present rock types. All but some of the Balaghat ores are in highly metamorphosed rocks of such antiquity as to be usually classified with the oldest rocks known in the region. Some of the Balaghat ores are in rocks that are as old but not as highly metamorphosed. They (the ores) occur as beds or lenses of varying extent and thickness. The ore is mostly psilomelane with

some hollandite ( a manganate of Mn, Ba and Fe). Some silicates of manganese, such as spessartite and rhodonite, have resulted locally from more pervasive metamorphism. In the more highly metamorphosed rocks the ore is different. Psilomelane is abundant only where the original bed was pure; otherwise, braunite, spessartite, and rhodonite are the ore minerals. Ore in the form of hollandite and sometimes rhodonite occurs as lenticles and nodules in the crystalline limestones of the district. In addition to these primary ores, secondary enrichment has helped form very rich deposits.

Next most important over the years are the "lateritoid"-type deposits.

#### Sandur District

Located in southern India, 300 miles northwest of Madras. The rocks are moderately highly metamorphosed rocks of the same age as those in the Central Provinces. There are chloritic, sericitic and biotitic phyllites ("chloritic," etc., means that the predominant mineral in the rock is chlorite, a "phyllite" is a metamorphic rock which is a transitional phase between slate and schist) and ferruginous quartzite (quartzite is metamorphosed sandstone; it is harder, denser, and more vitreous than sandstone). The deposits outcrop prominently but are not persistent in depth. Downward they give way to clay. For this reason, Fermor (6) thinks that the ore has resulted from local replacement of phyllite. It is more likely that leaching has been the major process, with substitution of secondary importance. Whatever the process, however, it is quite certain that ordinary tropical or subtropical weathering was the agency chiefly responsible for the changes that have taken place. The ore minerals are chiefly psilomelane and wad, with some pyrolusite and manganite. The ore runs about 45 percent Mn, 12 percent Fe, 1.0 percent SiO<sub>2</sub>, and 0.02 percent P. Reserves are estimated at 10,000,000 tons, much of it ferruginous.

The oldest and least-important type of deposit is the "kodurite" group. It is oldest in terms of both geological age and commercial production. The first ore produced in India came from Vizagapatam in 1892.

#### Vizagapatam District

This district is on the east coast, 500 miles southwest of Calcutta. The rocks are generally highly metamorphosed. There are two main rock types, a granite and a series of metamorphosed sediments. At the contact between these two is a "curious, highly calcareous gneissoid rock, consisting principally of pyroxene, wolastonite, scapolite,



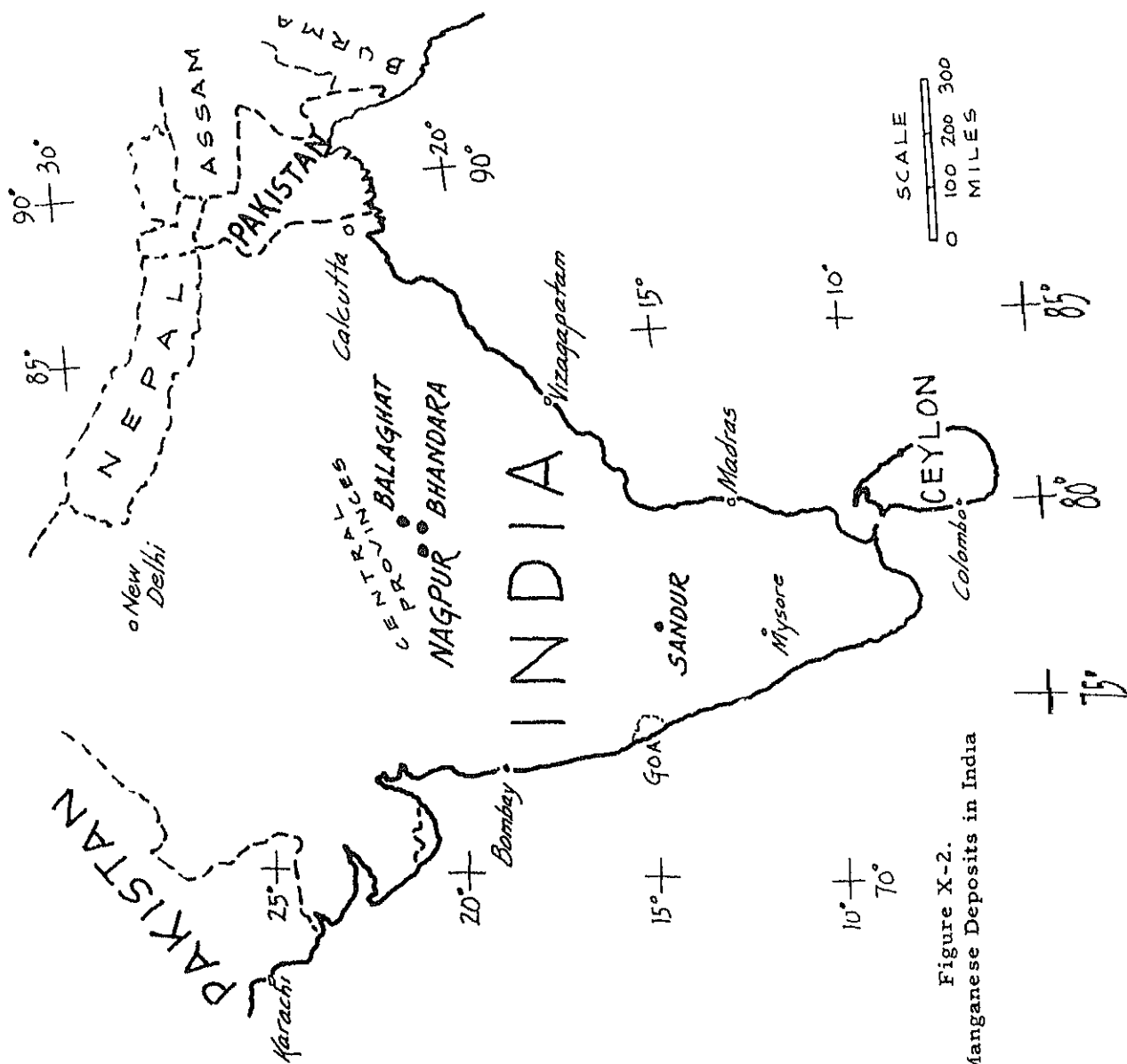


Figure X-2.  
Manganese Deposits in India

garnet, and sphene." (7) Ore rocks are most intimately associated with this last. They were originally thought by Fermor (8) to be of intrusive origin, for they consist of potash feldspar, manganese, garnet, and apatite, with or without quartz and pyroxene. The prevailing opinion at present is that rocks of the gondite type probably were invaded by the granite (mentioned above) and altered to their present condition. Surface weathering and enrichment have formed ore. The chief mineral is psilomelane; it is cavernous and usually contains some braunite. Pyrolusite is not uncommon. Mined ore contains 35 to 50 percent metallic Mn and often considerable Fe; less than 43 percent Mn and more than 15 percent Fe defines ferruginous Mn ore.

#### India Manganese-Ore Producers

As listed by Dunn (10) in 1942:

The firms responsible for the output of manganese ore in recent years are listed below. Of these, the Vizianagram Mining Co. is the oldest, and was floated in 1905. Most of the others were formed during 1905 to 1907. The more-recent concerns are those working in Bihar and Eastern States:

##### BIHAR

1. Dwarka Das Agarwalla
2. Arjun Ladha
3. Manji Bechar
4. Narendra Nath Kumar
5. Pacific Minerals Ltd.
6. Dhanji Kunverji Pandya
7. Hiralal Sarda
8. Sardar Bahadur Indra Singh
9. Kishanji Umarshi and Co.

##### BOMBAY

1. Kanara Mining Syndicate
2. Killick, Nixon & Co.
3. The Shivrajpur Syndicate

##### CENTRAL PROVINCES

1. The Central Provinces Manganese Ore Co. (name from Central Provinces Prospecting Syndicate in 1924).
2. The Central India Mining Co. went into liquidation in 1929.
3. The Indian Manganese Co.

4. Rai Bahadur Bansilal Abirchand Mining Syndicate
5. Jesraj Cheniram
6. Kanhaiyalal
7. Khan Bahadur M. M. Mullna
8. Oke Brothers
9. The Pacific Minerals, Ltd.
10. Shamji Naranji
11. Seth Mohanlal Jagannath
12. Seth R. B. Gowardhandass
13. Seth Shreeram
14. Thakur Lal Matuk Singh
15. Amritlal P. Trivedi
16. S. Abideen
17. Bhagwandas & Sons
18. B. P. Byramji & Co.
19. B. Fouzdar Bros.
20. Bhadulal & Harish Chandra Malguzar
21. Rambilas Murlidhar & Ors.
22. R. S. Seth Phulchand Agarwal
23. M. D'Costa
24. Nagarmall Poldar & Co.
25. G. H. Rawell & Sons
26. Bhagwanji Naranji
27. C. K. Ram Chowdhury
28. Bansidhar Ramniwas Goenka
29. Goswami Mahesh & Ram Krishna Puri
30. Ramchandra J. Poddar
31. A. H. Vasudave Rao & Bros.
32. Ganpat & Laxman Rao
33. Ganpat & Dhanpat Sao
34. Shrimant M. N. Ghaleti

#### EASTERN STATES

1. Bird & Co.
2. Tata Iron & Steel Co.
3. Hiralal Sarda
4. W. Young & Co.

#### MADRAS

1. Vizianagram Mining Co.
2. The General Sandur Mining Co.
3. Godigi Chennappa
4. Ashwani Rai Kumar Mining & Trading Co.
5. Indo-British Mining Co.

Table X-1. INDIA: MANGANESE-ORE PRODUCTION BY DISTRICT FOR SELECTED YEARS

(LONG TONS)

District	Location	1st. Yr.	1900 /1			1910 /1			1920 /2			1930 /3			1936 /4		
			Prod.	Rank	%	Prod.	Rank	%	Prod.	Rank	%	Prod.	Rank	%	Prod.	Rank	%
Vizagapatam	Madras	1892	92,008	1	66.1	46,441	5	5.8	7,386	8	1.0	13,213	8	1.6	15,258	5	1.9
Nagpur	Cent. Prov.	1900	47,257	2	34.9	211,232	1	26.4	221,912	2	30.1	150,133	3	18.1	119,360	3	14.7
Balaghat	Do.	1901	-----	-	-----	161,987	2	20.2	257,857	1	35.0	220,018	1	26.5	313,933	1	38.6
Bhandara	Do.	1901	-----	-	-----	159,164	3	19.9	90,949	3	12.3	155,023	2	18.7	134,710	2	16.6
Jhabua	Do.	1903	-----	-	-----	12,664	10	1.6	,	-	-----	-----	-	-----	-----	-	-----
Sandur	Madras	1905	-----	-	-----	73,666	4	9.2	-----	-	-----	145,961	4	17.6	102,966	4	12.7
Panch Mahals	Bombay	1906	-----	-	-----	30,396	8	3.8	34,166	5	4.6	36,542	5	4.4	28,994	6	3.6
Chitaldrug	-	-	-----	-	-----	-	-	-	-	-	-	-	-	-	-	-	-
Shimoga	Mysore	1906	-----	-	-----	42,518	6	5.3	21,761	6	3.0	18,802	7	2.3	1,559	7	.2
Tumkur	-	-	-----	-	-----	-	-	-	-	-	-	-	-	-	-	-	-
Chhindwara	Cent. Prov.	1906	-----	-	-----	19,556	9	2.4	51,517	4	7.0	27,170	6	3.3	803	8	.1
Ghanpur	Bihar-Orissa	1907	-----	-	-----	41,958	7	5.2	21,161	7	2.9	,	-	-----	,	-	-----
Total			139,265	2	100.	799,572	10	99.8	706,709	8	96.0	766,862	8	92.4	717,563	8	88.2
			-----	-	-----	800,907	all	100	736,439	all	100	829,946	all	100	813,442	all	100

# Manganese Ore

As reported by Dunn (9) in 1942:

Table X-2. COMPOSITION OF INDIAN MANGANESE-ORES AS EXPORTED

Classification: \*First-grade ore .....Over 48 percent Mn.  
 \*Second-grade ore .....Between 45 and 48 percent Mn.  
 \*Third-grade ore .....Below 45 percent Mn.

PROVINCE	EASTERN STATES			BOMBAY			
PRODUCER	BIRD & CO. (a) (e)			SHIVRAJPUR SYNDICATE (a)			
District or State	Keonjhar			Panch Mahals (Shivrajpur) (Bamankua) (b)			
Class of ore	1st grade	2d grade	Peroxide	1st grade	2d grade	Low grade	1st grade
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Manganese	48.0-50.1	38-42	54.4-58.85	50.0	46.50	44.0	48.0
Iron	7-6	14	1.7- 0.45	5.00	5.55	6.00	3.50
Silica	6-3	4	4.3- 0.78	3.20	8.50	11.00	8.50
Phosphorus	0.15-0.075	0.09	0.09	0.250	0.270	0.265	0.265
Manganese+Iron	55-56	52-56	56.1-59.30	55.00	52.05	50.00	51.50
Manganese peroxide	..	...	81.2-88.2	..	..	..	..

PROVINCE	CENTRAL PROVINCES			MADRAS STATES	MADRAS		
Producer	Central Provinces Manganese Ore Company (c)			General Sandur Mining Company Sandur (d) (e)	Vizianagram Mining Company (e)		
District or State	Balaghat, Bhandara and Nagpur		Bhandara (Dongri Buzurg).	Ferruginous manganese-ore	Vizagapatam		
Class of ore	1st grade	2nd grade	Peroxide		Manganese-ore	Ferruginous manganese-ore	Peroxide
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Manganese	48.66-53.19	45.25-50.47	52.36-57.95	39.8-40.95	44.1-45.2	35.0-39.6	..
Iron	4.17-10.33	5.73-12.21	1.25- 5.14	(f)	(f)	11.7-16.5	0.9-4.8
Silica	3.50-10.72	5.10-12.23	0.59- 2.59	(f)	(f)	(f)	..
Phosphorus	0.034-0.188	0.075-0.262	0.232-0.385	(f)	(f)	(f)	..
Manganese + Iron	54.77-59.82	52.46-59.16	57.50-59.20	..	..	49.2-53.2	..
Manganese Peroxide	..	..	83.90-88.10	..	..	..	76.1-91.6

- (a) Analysis of ore despatched.  
 (b) Lower grade ores also produced.  
 (c) Analysis of ore produced.  
 (d) Analysis of ore shipped.  
 (e) Figures for some years ago. Later figures not available.  
 (f) Not available.

**Table X-3. INDIAN MANGANESE-MINE OWNERS  
IN THE CENTRAL PROVINCES**

Owner	Post office address	Location of mines	Annual production, long tons
Shamji Naranji	Ramtek, Nagpur district	Chargaon, Ramtel	12,000
Seth Mohanlal Jaganath	Tumsar, Bhandara		12,000
Amritlal P. Trivedy	Balaghat	Manegaon Rawarbandhi, Pandharwani, Ramrama, Katengjhiri, Hirapur.	12,000
R. S. Seth Gopikison	Tumsar, Bhandara	Miragpur, Sukli, Kosumba, Belapur, Hamesha, Paonia, Hatoda, Selwal.	6,000
Jerone D'Costa	Tent Lines, Nagpur	Waregaon, Nawegaon.	6,000
Seth Sreeman Durgaprasad	Bhandara	Hatoda, Tirody.	5,000
Pacific Minerals Limited	Balaghat	Netra, Langhur.	5,000
Prakash and Company	Station Road, Balaghat	Gudi, Jagatare.	2,000
Nagarmall Poldar and Company	Empress Mill Road, Nagpur	Kiltchidhana	2,000
Rai Bahadur Bansilal Abirchand	Mining Syndicate Kamptee P. O. Nagpur	Chikla, Juniawana.	15,000
Cheniram Jesraj	c/o Jumnadhar Patda, Express Mill Road, Nagpur	Gula, Harki.	1,000
C. K. Ram Chowdhury	Kamptee P. O. Nagpur	Bhandabin, Gugalat.	
Goswami Mahesh, Ramkrishna Puri	Itwari, Nagpur	Chargaon.	900
			66,300

Reference: Mineral Trade Notes, vol. 27, No. 6, December 1948, p. 11.

Table X-4. MINING LEASES - CENTRAL PROVINCES - 1948

Owner	Post Office address	Location of mines	Estimated production, long tons
Harischandra Bhadulal	Tumsar	Bhandara	6,000
Madan Manohar	Kamptee	do.	
B. P. Byramji & Co.	Nagpur	do.	
Cke Brothers	do.	do.	
Beharilal Jhunjunawala	do.	do.	
F. X. Rebello	Tent Lines, Nagpur	do.	
S. Abideen	Nagpur	do.	
Seth Haji Latif Umar	Tumsar	do.	
Khan Badadur M.E.R.	Malak, Nagpur	Balaghat	
Lal Matuk Singh	Balaghat	do.	
R. P. Mudliar	do.	do.	
Diwanchand Jiwar	do.	do.	
V. V. Kothakar	Nagpur	do.	
Rai Sahib Jaipuria	Tumsar P. O.	do.	
Namdeo Pandurang	Bhandara	do.	
Rai Sahib M. G. Rungta	Bihar	do.	
Fatechand & Sons	Tamsar P. O.	do.	
Riazali Khan	Balaghat	do.	
Madhusudandas & Bros.	Bhandara	do.	
Sir. M. B. Dadabhoy	Nagpur	Nagpur	
The Registrar	Nagpur Univer.	do.	
Sir Tracy Govin Joanes	Gawnpore	do.	
Gangabai	Nagpur	do.	
A. H. Wasudeorao & Sons	do.	do.	
Ganpat Rao Laxman Rao	do.	do.	
Dhanji Deoji & Sons	Betul	do.	
N. D. Zal	Kamptee P. O.	do.	
Bansidhar Ramniwas Geonka	Nagpur	do.	
Seth Ghanshyamdas Ramnath	Tumsar	do.	
Haji Khawaja Miyan	Kamptee P. O.	do.	
Rai Sahib Seth Phulchand G.H. Rawell & Sons	Nagpur do.	Chhindwara do.	

Reference: Mineral Trade Notes, vol. 27, No. 6, December 1948, p. 12.

#### MAKRAS - Cont'd.

6. Harkarandas Mangilal
7. T. Ch. A. Naidu

#### MYSORE

1. The United Steel Cos. (formerly the Workington Iron & Steel Co.).
2. Oakley Duncan & Co., Ltd.
3. G. V. Raman
4. V. P. Mohomed Oomar Myian

#### D. INDOCHINA (FRENCH)

Production of 42-percent manganese ore commenced (11) in 1935 at the Yen-cu mine, near Vinh, on the northeast coast in the Province of Nghe-An. Production apparently has not been resumed since the war, although the grade was listed during the early war years as being in the 47-to 52-percent range.

#### E. INDONESIA

For many years Indonesia, formerly the Netherlands East Indies, has been one of the intermediate producers of manganese ore. Production is mainly from the early Kliripan and Penggoeng concessions in the Koelon Progo district, 15 kilometers west of Djokjakarta, Java, where the ore occurs as layers of pyrolusite, from 18 inches to 6 feet thick covered by silicified marl or breccia and underlain by limestone. The ore is remarkably pure and is said to contain from 85 to 95 percent manganese dioxide. Both chemical or battery grade (pyrolusite) and metallurgical grade have been shipped.

In 1918, O. B. Heldring estimated (12) the probable reserves of Java at 10 million tons. A later reference (13) indicates these reserves carry 47 or more percent manganese content.

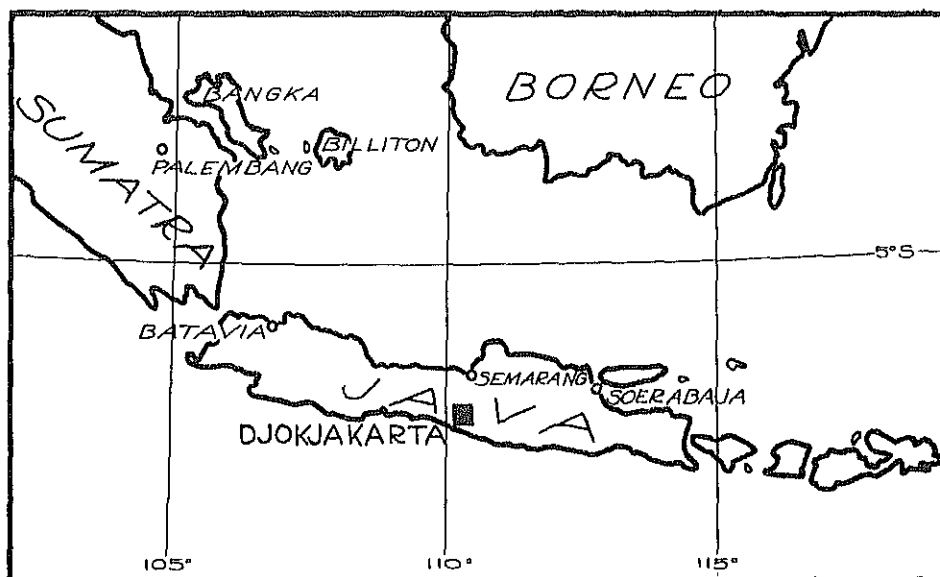
In recent years there have been two operating mines in Java; one in the west, 50 kilometers south of Tasikmalaja, the other in the south central part, near Djokjakarta (14). In 1940, the mine in western Java produced 80 percent of the total output. Both properties have been operated recently by A.I.M.E. (N. V. Algemeene Industriels, Mijnbouw en Exploitatiemaatschappij.)

Small deposits in southeast Borneo, near Marta Poera, are said (15) to have been operated before World War II by Mijnbouwmaatschappij Goenoeng Besi but produced only a few tons, which were



shipped from the port of Tjilatjap, on the south coast. Other manganese occurrences have been noted in Sumatra, Celebes, and other islands of Indonesia.

FIGURE X-1. MANGANESE DEPOSIT IN JAVA.



#### F. IRAN

The Robat Karum mine, 6 miles northwest of Shahryar, which is some 40 miles southwest of Teheran, was developed (16) by the Iranian Government before World War II to supply manganese to the Karaj Steel Works. Production of some 7,000 tons was reported during 1938-41. A concentrate was hand-sorted from the crude ore. The deposit consist of lenticular veins of manganese dioxide in calcite. Two grades of ore were reported, (17) containing 50 and 27 percent manganese, respectively. Reserves were estimated as of 1947 at 60,000 tons, metal content.

An earlier report (18) mentioned the discovery of a manganese deposit between Kirman and Jesd of an estimated size of 14 million tons.

#### G. JAPAN

Manganese-ore deposits occur throughout the Japanese Islands, but none of them is very large. Their combined annual production first exceeded 50,000 metric tons in 1934 and reached 100,000 tons during the war years. (19) This, along with imports from India,

Malaya, Russia, and the Philippine Islands, satisfies the need created by the domestic steel industry.

The islands of Japan can be divided roughly into the "Outer Zone" (Pacific side) of older, more or less simple rocks and structure, and the "Inner Zone" (Sea of Japan side) of more recent and more complex geology. Corresponding to these divisions are two modes of manganese occurrence. In the former, the ore bodies are of a residual nature; in the latter, they are metasomatic (replacement bodies).

Metasomatic ores occur as veins and irregular masses in sedimentary rocks of various kinds. Residual deposits are found as lenses along bedding planes. The oxide ore gives way in depth to rhodonite and rhodochrosite. Chemical ores average 82 percent  $MnO_2$ , and metallurgical ores run 43 to 56 percent Mn, 7 to 10 percent  $SiO_2$ , and 0.5 percent P. (20)

The main producing mines in Japan, as well as the prefecture in which each is located, are listed in table X-5. (Compare index numbers with numbers on the map.)

Table X-5. MANGANESE MINES IN JAPAN /I

Prefecture	Index number	Mine
Aomori	4	?
Ehime	15	Fushikoshi
		Kuzu
Gifu	10	Emi
		Kurakai
		Mabuki
		Takahashi
Gumma	8	Manba
Hiyama	3	Meppa
Ishikawa	11	Searashi
Iwate	5	Atuta-Tamagawa
		Hinosawa
		Takomatsu
		Tamagawa
Kagoshima	18	Yamoto
Kochi	16	* Anauhi
Kyoto	14	Hikofani
		Gohodoni
		Takehashi

Table X-5. MANGANESE MINES IN JAPAN /1 Cont'd.

Prefecture	Index number	Mine
		Kawa Kami Matabayashi Michiokutani Nakayama Omiya Tanba
Nagano	9	Karakizawa Tatsushima
Oshima	2	Yagumo
Shiga	13	Tsuchikura Yaei
Shiribeshi	1	* Inakuraishi Oe Pirika * Shikaribetsu
Shizuoka	12	Takaroka
Tochigi	7	Kawazu Hakkoji Kawamo Kaso Konakayama Manako Momokawa
Yamagata	6	Nagano Tatsumori

/1 Mineral Resources of Japan, work cited in footnote 19.

\* Leading producers.

Of all the producers listed, the Anauchi mine in Kochi and the Inakuraishi and Shikaribetsu mines in Shiribeshi, Hokkaido Island, are the leaders.

On the following page is a map showing the manganese deposits of Japan.

# MANGANESE MINES & DEPOSITS JAPAN

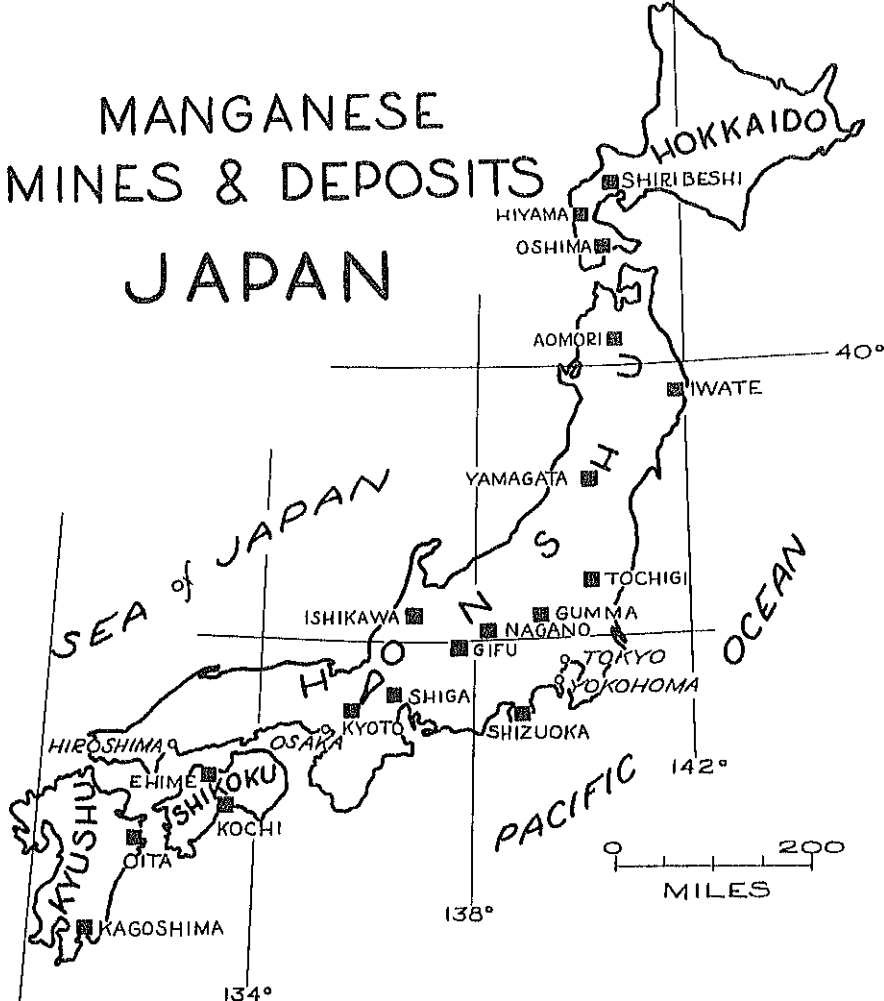


Figure X-2. MANGANESE DEPOSITS OF JAPAN

## H. MALAYA

The commercial manganese deposits of Malaya, in the States of Kelantan and Trengganu, are thought to have been nearly depleted before World War II, although they were worked by the Japanese during the war with the product exported to Japan. Shipping grade has been listed in the part as 30 percent manganese content. There has been no production since the war.

Following is reported (21) production and exports to date:

Year	Production			Exports
	Kelantan	Trengganu	Total	
1925-29		182,789	182,789	----
1930-34	11,884	58,780	70,664	----
35	10,678	17,780	28,045	28,045
36	10,006	26,770	36,776	36,776
37	9,667	23,126	32,793	32,793
38	8,916	23,054	31,970	31,970
39	11,548	19,900	31,448	31,448
1940	3,141	8,400	11,541	----
41	3,635 <u>/2</u>	----	3,635 <u>/2</u>	----
42	----	----	----	----
43				
44	1,000	900	10,900	3,000
45				
46	----	----	----	----
47	----	----	----	----
48	----	----	----	----
49	----	----	----	5
50	----	----	----	71
51				192
52				
53				
54				
55				

/1 In long tons.

/2 The first nine months only.

# I. MANCHURIA

It has been reported that manganese deposits, estimated to contain 10,000,000 tons, were discovered in 1940 at Hsihsien, Chinchow Province, Manchukuo. (22)

It is thought, however, that the above must refer to the Wafangtzu deposit in Jehol Province, which had been reported (23) erroneously as being in Chinsi-Hsien in western Liaoning Province. This deposit is believed to contain some 3 million tons of less than 30-percent

manganese content.

## J. PALESTINE

Manganese ores are found at the base of the Nubian sandstone in the Akaba district of Palestine, some 17 miles north of the Gulf of Akaba. Reserves were estimated at 500,000 tons in 1938, when Groves (24) referred to this area. A large sample of this ore was stated to contain 64.12 percent  $MnO_2$  with 0.8 percent copper.

## K. PHILIPPINE ISLANDS

The existence of manganese ore in the Philippines has been known for some time; the first discovery was made in 1906. It is probably the commonest mineral in the islands. In almost every Province, fragments of manganese deposits have been prospected, explored, or reported. Grade of the ore is often high, running from 45 to 50 percent, but in almost every instance the ore is so mixed with gangue material that much sorting, either mechanical or by hand, is necessary.

Ore has been reported in at least 25 localities on Busuanga, Siquijor, Bohol, Mindanao, Leyte, Samar, Luzon, and several other islands in the archipelago. Of these, the deposits on Busuanga, Bohol, and Siquijor Islands, and the Caramoan Peninsula on Luzon have furnished virtually all the production to date.

Of the four major districts, the bulk of the activity is concentrated in Busuanga. Layers of manganese ore are embedded in chert and jasperoid. The predominant ore mineral is psilomelane, mixed with some pyrolusite; The ore runs better than 50 percent manganese and is low in iron and phosphorus. The thickest ore body is reported to be 18 feet thick and 40 feet long. Structurally, the deposits are very complicated, the beds being broken and badly twisted. The origin of the deposits is obscure. They have been reported as "typically marine" (47) and as possibly hydrothermal (25). Reserves in Busuanga have been estimated at about 1,000,000 tons (26).

Virtually all of the island of Bohol is one great manganese deposit, but the mode of occurrence makes the minable reserve a very questionable quantity at best. All the ore seems to be of a residual nature; it is strictly surficial, is mixed intimately with alluvial material and organic matter, and is usually powdery. Occasional pockets of high-grade ore are found. The ore is exceedingly hygroscopic;

the moisture content varies from 3 to 18 percent, depending on the season. No water is available for treating the ore by jigging, and there is no fuel to clinker it if it were ground first. For these reasons and perhaps others development and exploitation in Bohol are not being pushed very hard. The reserves have been estimated at "anywhere from 2,000,000 to 10,000,000 tons." (27)

In Siquijor the ore is similar in character to that in Bohol but differs in occurrence. It is very impure but occurs as beds instead of surficial cappings. The chief manganese mineral is pyrolusite, occurring as a bedded deposit similar to a coal measure (28) with an average thickness of 12 feet. Folding and widespread faulting, uplift, erosion, and channeling have affected the ore horizon so that it is twisted and offset and missing in places, all of which complicate the mining picture. In addition to the complicated structural features of the ore bed and the low grade, no timber is available on the island. As a result, all the timber used to hold underground workings open has to be imported. No reliable figure has been found for the reserves; they have been estimated at 70,207 tons proved, 210,292 tons probable (280,499 tons total), (29) to as much as 2,000,000 tons. (48)

From San Miguel Bay south to Sorsogon, the Caramoan Peninsula is virtually one series of manganese deposits of different sizes and grades. The leader of the two that have produced is at San Miguel Bay. It consists of a series of manganese-ore boulders embedded in red clay. The boulders vary in size from a few kilograms to over 5,000 tons. The ore is of excellent quality; shipping grade was over 53 percent. It is very dense and heavy, and low in iron and phosphorous. The ore occurs right along shore, from where it is loaded onto barges and transferred to ocean-going vessels.

The origin of the Philippine manganese ores is, as was pointed out, controversial. In the main, however, they are thought to be primary sedimentary deposits, which in most instances have been strongly folded but without much attendant metamorphism. The ultimate source of the manganese was formerly thought to have been the basalts and other igneous rocks of the Islands themselves. (30) More recent opinion, however, is that the Islands themselves are not large enough to have supplied enough material to form such extensive deposits. It seems probable that at the time that the ores were laid down, the Islands did not exist as such. Rather, they were submerged areas on the continental shelf, and the source of supply was quite far removed. (31)

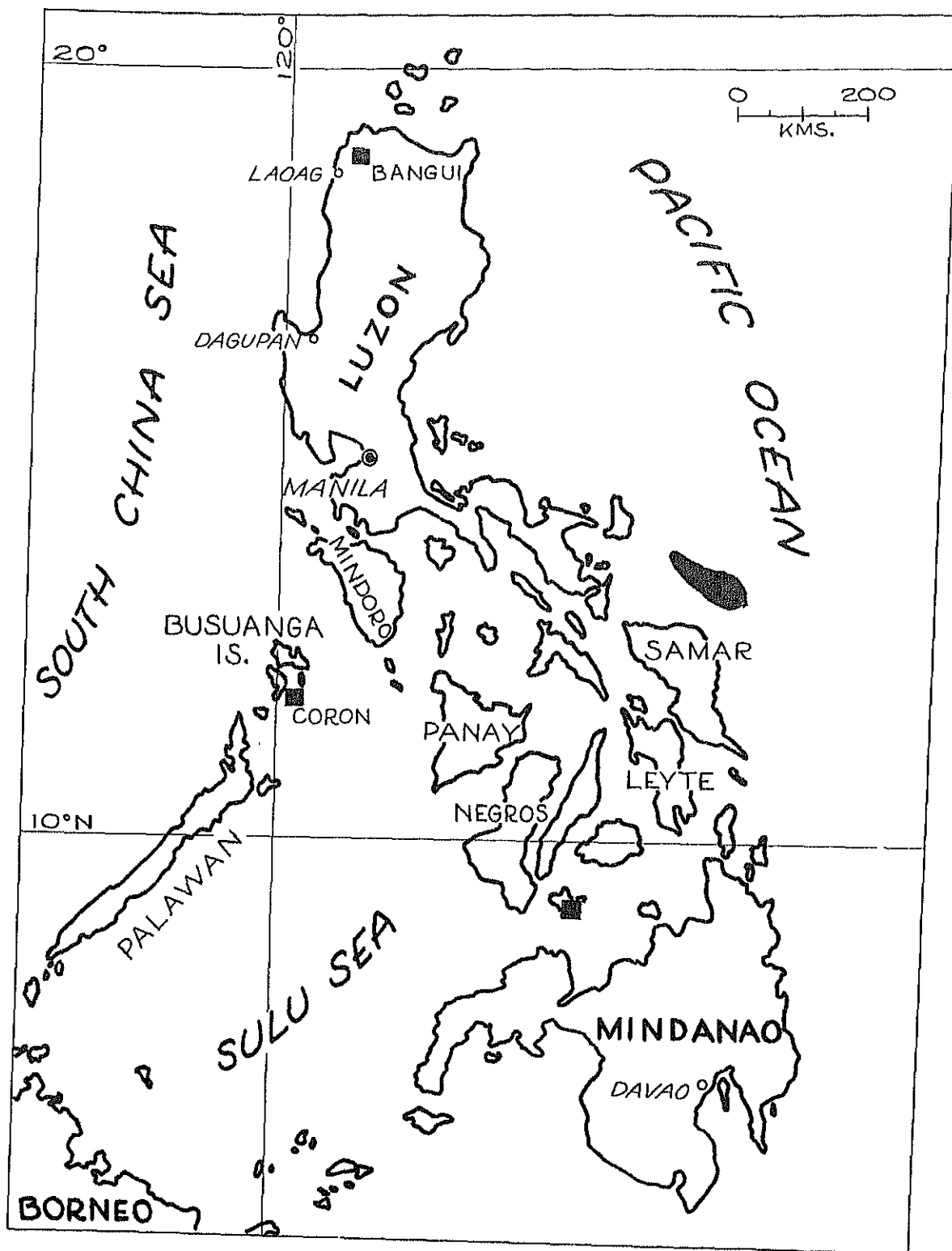


FIGURE X-4. Manganese deposits of the Republic of the Philippines



## L. PORTUGUESE INDIA (GOA)

Groves (32) states that the low-level laterites of Goa are highly manganiferous in a number of well-distributed localities but that the deposits occur so irregularly and are so variable in composition that they now are comparatively unimportant compared with their former position.

Most of the early development work, following discovery of manganese in 1906, centered (33) around the Thummaraguddi mine in the district of Bellary.

Recent reports (34) indicate a postwar revival with mining well-organized but primitive. Transport from mines to port is river borne by small sailing craft. Current production is reported to be well over 2,000 tons a month with plans to increase annual capacity to 85,000 tons. Grade of ore ranges from 42-to 52-percent manganese. Mines are either owned or leased privately.

With no export tax or control over exports, Goa has become quite a trading center through which much Indian ore is handled. A list of dealers and producers, as of 1948, (35) is given below.

### Manganese dealers and producers in Goa.

1. Annaji Narmona Mallapur, Sanguam, Goa, Portuguese India.
2. Baptista de Silva & Company, Ltd., Caixa Postal 41, Cidado de Goa, Portuguese India.
3. Esjoda Mining Corp., 20 Podar Chambers, Parsee Bazar St., Bombay, India.
4. A. C. James & Co., 6 Mahomed Building, Military Square, Bombay, India.
5. Francisco Xavier de Azavedo, Margoa, Goa, Portuguese India.
6. Goa Express Commerical Agency, P.O. Box 56, Nova-Goa, Portuguese India.
7. J. S. Gomes, Margoa, Goa, Portuguese India.
8. Hormusji N. Hormusji, P. O. Box 56, Nova-Goa, Portuguese India.
9. E. Loeffler & Co., Noble Chambers, Parsi Bazar St., Portuguese, Bombay, India.
10. Narandas Girdardas, Madrasta, Goa, Portuguese India.
11. Xec Abdulcader, Sanguam, Goa, Portuguese India.

Private reports indicate that Baptista de Silva & Company was the most active firm in 1951-52 with Indian firms virtually out of business.

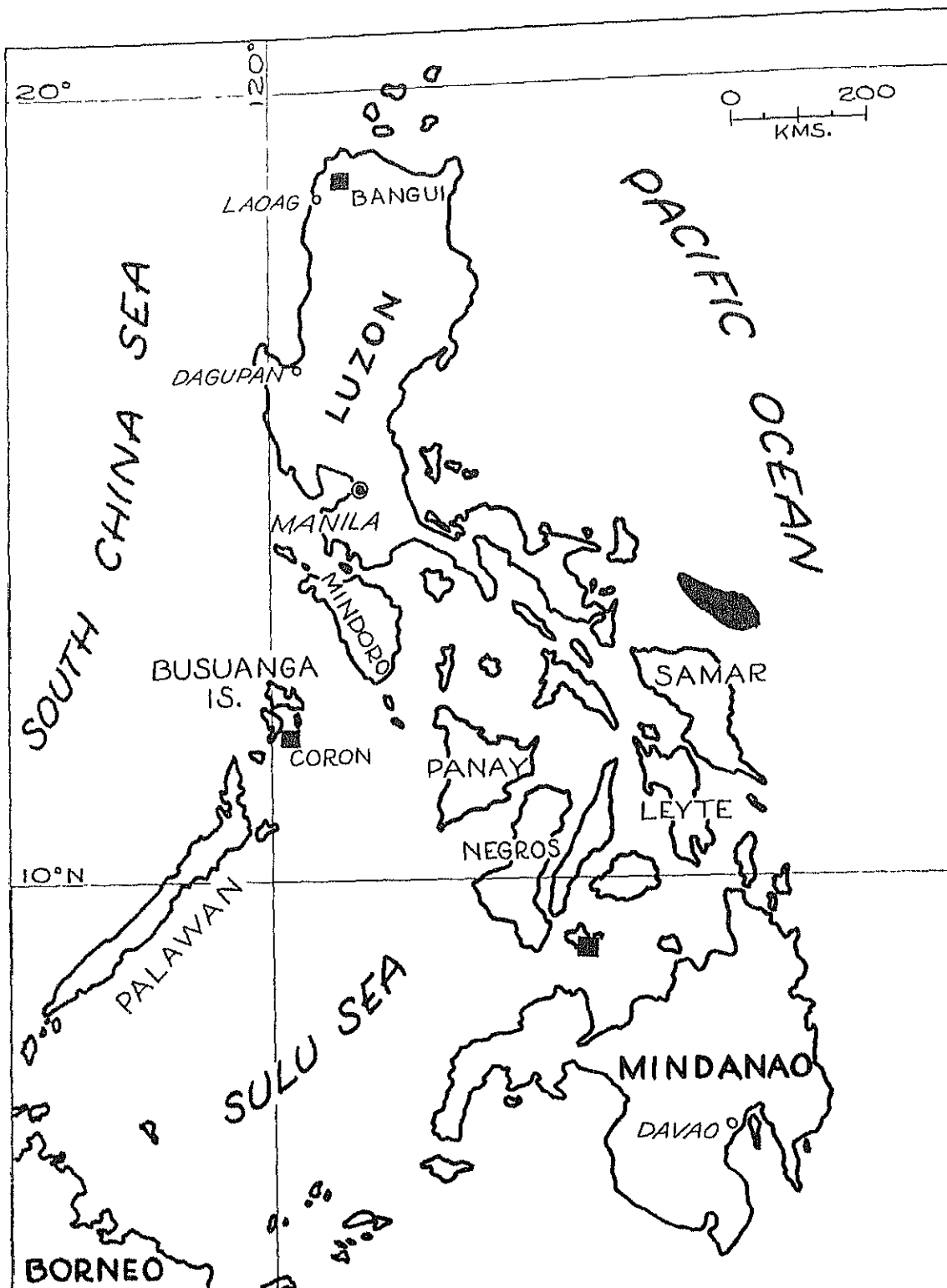


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Mines at Nikopol in southern Ukraine and at Chiatury in the Caucasus are the mainstay of Russian manganese production. About 90 percent of total output and virtually all ores for export come from these two long-time producing areas. Minor producing areas include Marsiata, Polunochnoye, Baimak, and probably Beloretsk in the Urals; probably Dzhezdy, Kara Dzhal, and Naizatas in Kazakhstan; and Mozulskoye, near Achinsk, in western Siberia. These minor producers, of which Mozulskoye appears to be the largest, are tributary to steel plants in the Urals and farther east. Future production may also come from the deposit formerly worked at Labinsk (Laba, Kuban), near the Maikop oil fields north of the Caucasus and from the Mangyshlak deposit in rather remote desert country on the east coast of the Caspian Sea. In addition, there are numerous other deposits as listed in table X-8 and noted on the map of Figure X-5.

Chiatury District (Chiatura, Chiaturi, Tchiaturi)

These districts are in the Kutais region, Georgia, on the south slope of the Caucasus Mountains at an altitude of 2,000 to 2,500 feet. The mining area, some 19 miles long by 5 to 6 miles wide, (36) is serviced by an aerial tramway to a 21-mile spur of the mainline of the Trans-Caucasus Railway, which carries the ore to Batum (126 miles) or Poti (90 miles) on the Black Sea.

Chiatury is the largest-known single manganese deposit in the world and largest single producer of high-grade ore. The original mineral zone, triangular and some 40 square miles in area has been eroded by canyons as much as 800 feet deep on both banks of the Kvirila river, leaving a mineral area of about 14 square miles. The associated rocks are sandstones, shales, and chinks of Cretaceous to Miocene age (25 to 60 million years old). They are irregularly bedded, dipping about 2 and 1/2 degrees northeast. The ore bed "contains intercalated layers of sandstone or of loose, friable, calcareous (limy) and arenaceous (sandy) rock, which vary in thickness from a small fraction of an inch to 10 inches or a foot." (37) The entire manganese bed averages 6 to 7 feet in thickness (range, 6 to over 10 feet) the ore being uniformly 3 feet thick.

The ores, of sedimentary origin, consist of pyrolusite, psilomelane, braunite in lumps, and wad. They are concretionary, oolitic, and tend to be powdery; large chunks are rare. Grade is uniformly 48-49 percent manganese, 6-10 percent  $\text{SiO}_2$ , 0-1.8 percent Fe, and 0.15-0.18 percent P. Top grade is 52 percent Mn; concentrates contain

80-90 percent  $MnO_2$ .

The Chiatury deposits have been mined for over 70 years, and are more widely known than any other deposits. From 1925-28, A. Harriman operated them as a concession. They were explored by some 20,000 feet of drilling in 1934-35. Total reserves are some 160 million tons of ore, containing 78 million tons of manganese.

For 2 miles along the cliff faces, adits (tunnels) give entry to the mines. Mining is by the longwall retreating method, using narrow pillars and allowing the roof to cave behind the workings. Considerable timber is used for roof support. The ore is soft and is drilled by electric augers. The mines are equipped with machine loaders and electric haulage. Early mining and forced production during World War II is understood to have been wasteful.

About one third of the ore is shipped crude, the balance is concentrated in the ratio of 2-1/2 - 3:1, with 80 percent recovery, by means of log washers, jigs, screens, tables, and sometimes sintering to a grade of 52-55 percent Mn, 4-8 percent  $SiO_2$ , 0.4-1 percent Fe, and 0.15-0.19 percent P.

The largest plant in the area was reported in 1938 (38) to have a capacity of 2,000 tons per day. It used jigs for coarse concentration with tables and sintering for the finer material.

The Chiatury deposits produced 1 million tons of ore in 1947; it is understood that 2 million tons were planned for 1950.

#### Nikopol District

This district is in southern Ukraine on the right bank of the Dnieper River below the town of Zaporozhe. The district has some 20 operating mines with output of 4,000 tons per day and is divided into eastern and western fields, 10 to 15 miles apart, by a barren zone of crystalline rocks. Production began in 1886. The western field, 12 miles long by 6 miles wide, contains the Alexandrovski group of mines, largest in the district. In the eastern field five separate ore bodies (39) of the same type have been outlined. The area underlain by manganese ore is said (40) to be 150 square kilometers.

The manganese ores occur as nodules, oolites, and concretions in a horizontal bed 3 to 12 feet thick and averaging 6 and 1/2 feet of Paleozoic marine sediments, mainly sandy clays. The bed rests on a basement of pre-Cambrian granite. Pyrolusite is the chief ore mineral, with psilomelane and, rarely, manganite.

Shafts 50 to 100 or more feet deep afford entry to the ore bed; mining is done by the longwall method, allowing the roof to cave behind the workings. Extensive timbering is required. In 1938 the output of crude ore per man shift was given (41) as 1.5 to 2 tons, although other observers of iron and coal mining in the Ukraine consider 1 ton per man per day a better figure.

The crude ore, 3 tons of which make one ton of concentrate, analyzes (42) 20 to 36 percent manganese, the average being about 30 percent. Other constituents are, approximately,  $\text{SiO}_2$ , 30 percent; Fe, 3 percent; and P, 0.2 percent.

The mine product is hand-sorted, crushed, deslimed in log washers, and concentrated by tables, flotation, or magnetically with about 75 percent recovery to three products ranging from 33 to over 57 percent in manganese content. In the past, most of the Nikopol product was used in nearby steel centers, with only the highest grades available for export. Undoubtedly, this situation has been altered somewhat with the growth of steel centers to the east. It is understood that the low-grade product, in recent years, has been used for manganese pig iron, with the better grades going to steel and ferro-alloy plants. Up to 20 percent of output has been exported in two grades: (a) 48 to 51 percent Mn, 7.5 to 10.5  $\text{SiO}_2$ , 0.7 to 1.2 Fe, and 0.16 to 0.22 P, and (b) 42 to 44 percent Mn, 13 to 15 percent  $\text{SiO}_2$ , 1.5 to 1.9 percent Fe, 0.17 to 0.25 percent P.

Capacity production for the district exceeds 1,200,000 tons per year.

Reserves of all classes of ore have been estimated at 396,000,000 tons, containing about 121,000,000 tons of manganese metal.

#### Other Districts

Brief descriptions follow some of the less prominent manganese areas throughout the U.S.S.R. Several are recent developments, as yet not fully exploited, that have been brought about by the need for supplies tributary to Magnitogorsk, the Kuznets Basin, and the steel plant at Petrovsk near Lake Baikal. The map gives localities. Much less published information is available on these districts than for the larger and older producing areas at Chiatury and Nikopol.

Khoschevatka - Manganiferous iron ore of 18 percent manganese and 28 percent iron content in a mineralized zone 6 miles long by one-half mile wide. Individual lenses range from 6 to 25 feet in thick-

ness and up to about 125 feet in length. Although the deposit contains over 3 million tons of possible ore, it is not worked.

Laba (Labinsk, Kuban) - A major deposit of nearly 34 million tons of ore carrying 17 to 24 percent Mn, 40 to 45 percent  $\text{SiO}_2$ , and 3 to 4 percent Fe. The manganese content of the deposit is estimated at 7.1 million tons. The deposit is sedimentary, consisting of a sandstone layer 1-1/2 to 3 feet thick, in which psilomelane and pyrolusite are the cementing materials. The surrounding formations are Tertiary limestones, marls, etc., and the mineralized zone extends some 6 miles. By fine crushing and magnetic separation, a 40-percent manganese concentrate may be produced. The deposit was worked in 1931 but has not been reported in operation recently.

Azhamety-Chkhary - Three distinct local areas in the Kutais region, Georgia, some 20 miles south of Chiatury, where psilomelane and oolitic beds outcrop for about 12 miles in Oligocene (granite and sandstone) and pre-Cambrian (limestone and chalk) formations. The ore-bearing beds dip  $30^\circ$  southeast and are understood to contain 35 to 37 percent Mn, 14 to 18 percent  $\text{SiO}_2$ , 2 to 7 percent Fe, and 0.3 to 0.5 percent P. The deposits have been worked but apparently are being held idle in favor of the Chiatury operations. Proved reserves are small, although there may be prospects for additional tonnages.

BelyKluch (Agbulakh) - Steep-dipping lenses of psilomelane and pyrolusite up to 30 feet in length and 5 feet in thickness are estimated to contain a possible 3.6 million tons of 42 to 56-percent manganese grade.

Polunochnoye - Horizontal beds exposed for a mile along both banks of the Polunochnoye River; these are 2 feet thick on the right bank and 10 to 30 feet thick on the left bank. Ore minerals are pyrolusite, psilomelane, wad, and carbonates. The oxide ore is understood to carry 18 to 25 percent Mn, 35 to 45 percent  $\text{SiO}_2$ , and 4 to 6 percent Fe; the carbonate ore, 1 to 26 percent Mn, 26 to 53 percent  $\text{SiO}_2$ , and 4 to 5 percent Fe. The crude ores will concentrate to 50 percent manganese content. Reserves are given at 1.3 million tons, and the product is probably used in the steel plant at Serov.

Marsiata - A relatively small, flat-bedded, low-grade pyrolusite and carbonate deposit in Oligocene sandstones. Crude ore runs 20 to 27 percent Mn, 22 to 31 percent  $\text{SiO}_2$ , 5 to 9 percent Fe. Oxide reserves are small but some 2 million tons of carbonate ore listed as possible. Formerly an important local supplier.

Baimak Group - Possible additional tonnage of open-pit psilomelane and pyrolusite ores containing up to 56 percent manganese. Present production from Faizulla deposits trucked to Magnitogorsk, about 80 miles.

Mangyshlak - A major deposit of over 32 million tons carrying approximately 22 percent Mn and 3 percent Fe, but located in remote desert territory where water will be difficult to obtain for concentration. Content of contained manganese, about 7.2 million tons. The manganese minerals, psilomelane and pyrolusite, are found as concretions, similar to Chiatury and Nikopol, in an orebed interlayered with sandstone and 5 to 12 feet in total thickness. The deposit has not yet been exploited.

Kara-Dzhal - An important deposit of high-grade ore suitable, without treatment, for making ferromanganese. Ore seam 5 to 12 feet wide extends for 3 miles. Minerals are braunite and psilomelane, partly iron-free but also mixed with hematite.

Naizatas - Lens-shaped beds containing 40 or more percent manganese. Indicated reserves are minor in amount but may have been increased, as the property has been recently.

Shointas - A deposit, some 600 feet long, of psilomelane and braunite carrying about 45 to 52 percent Mn and 34 to 39 percent SiO<sub>2</sub>.

Mozulskoye - An important, possibly major, deposit in the outskirts of Achinsk. Developed in the mid 1930's to supply the open-hearth steel plant at Stalinsk in the Kuznets Basin, which depended on Chiatury for manganese ore. Deposit consists of 10 flat beds or pockets ( of which 4 are considered large ) of psilomelane, pyrolusite, and manganite averaging about 18 percent Mn, 16 percent Fe, 0.3 percent P. The ore beds range from 9 to over 80 feet in thickness in an area 12 miles by 1/2 mile in extent. In 1936 underground development was begun by sinking 12 shafts, 6 of which are said to have encountered ore of 45 percent manganese content; one is a deposit some 200 feet thick. Proved reserves were stated in 1935 at over a million tons.

Lake Baikal Area - Small veins and beds of pyrolusite and manganite in limestone. Content reported as 10 to 33 percent Mn, 3 to 34 percent SiO<sub>2</sub>, 1 to 9 percent Fe, and up to 0.4 percent P.



### Sources of information

Table X-7 is a list of the annual review volumes of the Federal Geological Survey and the Federal Bureau of Mines that contain significant information on the Russian manganese deposits and industry:

Table X-7. MINERAL RESOURCES OF THE U.S.S.R.

Year	Page	Year	Page
1883-1884	p. 555	1919	p. 117
1886	pp. 204-205	1926	p. 161
1888	p. 141	1927	p. 194
1892	pp. 214-215	1928	p. 245
1893	pp. 138-145	1929	p. 321
1897	pp. 114, 120	1930	p. 325
1899	pp. 159-162	1931	p. 177
1900	pp. 125, 137, 140	<u>Minerals Yearbooks</u>	
1901	pp. 136, 152	1935	p. 484
1902	pp. 143, 137-140	1936	p. 440
1903	pp. 152-153	1937	p. 631
1905	pp. 105, 111	1940	p. 589
1911	pp. 203-206	1944	pp. 600-601
1912	p. 220		

### Reserves

Total reserves of manganese ore in the U.S.S.R. have been estimated at about 650 million metric tons, suitable either for direct shipment or for production of standard-grade concentrates. Of this total, about half may be considered reasonably assured, with the balance more or less prospective.

Although Kostov's (43) estimate of 652 million tons of 41-to 48-percent manganese content is the latest available, his figure appears to have been based on the earlier and more detailed estimate of Betekhtin (49) in 1935, a full tabulation of which is included here as table X-8. This survey, it will be noted, covered some 60 deposits, with individual estimates broken down according to a scale of relative assurance. The standards used by Betekhtin in setting up the several classes of prospective ore are not clearly defined in his report, as the letters A, B, and C have been used instead of the customary terms. In view of the totals listed for the several classes and the data given for the well-known producing areas, it would appear that categories



Table X-8. U.S.S.R. - ESTIMATED RESERVES OF MANGANESE-ORE DEPOSITS, 1935 /1  
(Thousands of metric tons)

Location and deposit	Relative assurance classification					Remarks	Page 1 of 6
	A <sub>2</sub>	B	C <sub>1</sub>	Subtotal A <sub>2</sub> +B+C <sub>1</sub>	C <sub>2</sub>		
<u>Ukraine</u>							
Khoshchevato	-----	338	352	740	3,340	Pyrolusite and psilomelane.	
Nikopol group.	42,281	46,590	---	88,871	307,000	Pyrolusite, psilomelane, rarely manganite. 2 mineralized areas, eastern field and western field.	
Total Ukraine	42,281	46,978	352	89,611	310,340		
<u>Middle Volga</u>							
Kvarkeno region	2	3	---	5	----	Pyrolusite, psilomelane, and wad.	
Total Middle Volga	2	3	---	5	----		
<u>North Caucasus</u>							
Laba (Kuban)	-----	-----	33,900	33,900	----	Psilomelane and pyrolusite.	
Total North Caucasus	-----	-----	33,900	33,900	----		
<u>Georgia</u>							
Azhmety-Chkhary,						Psilomelane and pyrolusite.	
Kutais region	60	-----	---	60	----	Psilomelane, pyrolusite, manganite.	
Chiatury	57,599	49,292	55,816	162,707	----	(Added note - Mgyimevi deposit of carbonate ore discovered by Betekhtin near Chiatury.)	
Bely-Kluch group (Agbulakh)	-----	-----	---	-----	3,580	-----	
	57,659	49,292	55,816	162,767	3,580		

/1 After Betekhtin, A. G., and Bagratuni, E. G., Mineral Resources of U.S.S.R.; Manganese: Bull. 7, 1935.

Location and deposit	Relative assurance classification					Remarks	Page 2 of 6
	A2	B	C1	Subtotal A2+B+C1	C2		
Azerbaijan Molla-Djala (Narimandy region)	-----	-----	-----	-----	50	Siliceous ferruginous manganese ore.	
Total Azerbaijan	-----	-----	-----	-----	50		
Sverdlovsk Province Klyktansvskoye.	-----	-----	550	550	-----	Soot-manganese ore.	
Visim-Shaitan region	-----	-----	600	745	-----	Manganiferous limonite, wad, and carbonate ores.	
Berizovskoye	-----	145	6	8	-----	Pyrolusite and carbonate.	
Lozva Landing Place	-----	317	1,340	2,607	-----	Pyrolusite, psilomelane, wad, and carbonate. (Added note-2 layers, pyrolusite, upper, carbonate lower, grade 10-25 percent manganese.)	
Polunochnoye	950						
Tynya	-----	7	790	797	-----	Psilomelane and rhodonite.	
Kushva region	-----	-----	-----	-----	50		
Kazanskoye	-----	-----	-----	-----			
Kabakov (Nadezhdinsk) region.	-----	-----	-----	-----			
Yelovka	-----	-----	65	65	-----	Pyrolusite.	
Marsiata	-----	25	120	145	2,000	Pyrolusite and carbonate.	
Petropavlovskoye	-----	-----	83	83	-----	Manganiferous limonite.	
Tynshanskoye	-----	-----	30	30	-----	Pyrolusite and psilomelane.	
(Garnichnaya Razvedks)							
Nevya region	-----	-----	-----	-----	10		
Alexandrovskoye	-----	-----	-----	-----	3		
Rudianskoye	-----	-----	-----	-----			
Nizhny-Taghil region	-----	-----	-----	-----			
Sapalskoye	11	18	13	42	-----	Rhodochrosite, manganomagnetite pyrochroite, and hematite (reported now depleted after 53 years operation).	
Mt. Lipovaya	-----	4	-----	4	6	Earthy, friable clay and wad mixture.	
Cheriomukhovoye Stoilo	-----	-----	10	10	-----	Friable, hydrated iron clay and wad.	

Location and Deposit	Relative assurance classification				Remarks	Page 3 of 6
	A <sub>2</sub>	B	C <sub>1</sub>	Subtotal A <sub>2</sub> +B+C <sub>1</sub>		
Sverdlovsk Province, cont'd.						
Pokrovsk region, group of 5 mines /2	5	-----	-----	5	-----	
Sysert region	-----	-----	-----	-----	-----	
Afonasyevskoye	-----	-----	-----	-----	10	
Kamenskoye	-----	-----	-----	-----	20	
Sverdlovsk region	-----	-----	-----	-----	8	
Sedelnikov	-----	-----	-----	-----	-----	
Chusovaya region	-----	-----	20	20	-----	
Beriozovsky	-----	-----	-----	-----	-----	
Total, Sverdlovsk Province	966	518	3,627	5,111	2,107	
Cheliabinsk Province						
Magnitogorsk region	-----	2	2	4	-----	
Bai-Bakhta I	-----	2-	-----	20	-----	
Bai-Bakhta II	-----	-----	1	1	-----	
Trebinskoye (Gumbeika R.)	-----	-----	-----	-----	-----	
Total Cheliabinsk Province	-----	22	3	25	-----	
region group	40	30	150	220	-----	
	-----	-----	-----	650	-----	

ednie-, Bolshoi-, and Novo-Pokrovsky, and Andreyevsky.

Location and deposit	Relative assurance classification					Remarks	Page 4 of 6
	A <sub>2</sub>	B	C <sub>1</sub>	Subtotal A <sub>2</sub> +B+C <sub>1</sub>	C <sub>2</sub>		
<u>Bashkiria cont'd.</u>							
Beloret'sk group							
Gabdimovo	4	18	243	265	-----	Silicate ores, oxidized upper part.	
Naizgulovo I	180	126	199	505	-----	Group of 9 deposits now under	
Naizgulovo II	40	61	125	226	-----	development near Magnitogorsk,	
Kazgan-Tash	-----	4	42	46	-----	containing 2.8 million metric tons	
Bikkulovo	57	48	630	735	-----	rather good quality ore.	
Kusimovo	50	106	391	547	-----		
Ayusazovo	11	20	31	62	-----		
Yalimbetova	31	50	34	115	-----		
Kyzyl-Tash	5	34	104	143	-----		
Others	-----	26	97	123	-----		
Baimak group							
South Faizulla	22	13	16	51	-----	Psilomelane and pyrolusite.	
North Faizulla	-----	10	108	118	-----	(Note-2 other deposits, Uchoyle	
Ianzighitovo	31	35	64	130	-----	and Ulu-Telyak, are listed for	
						the Baimak region but no data	
						given.)	
Total Bashkiria	471	581	2,884	3,936	-----		
<u>Kazakhstan</u>							
Mangyshlak	-----	-----	32,760	32,760	-----	Psilomelane and pyrolusite, near	
						Caspian Sea, northeast coast.	
Dzhezda (Dzhezdy)	-----	45	-----	45	-----	Psilomelane with pyrolusite impurities	
						in south Kazakh. (Added note, Mn	
						25-55 percent, average 32 percent,	
						low Fe, few impurities; Mn:Fe ratio	
						very high, over 15:1.)	
Naizatas	-----	-----	493	493	-----	Psilomelane, with pyrolusite	
						impurities; south of Dzhezda.	
Shaintas (Shointas)	-----	-----	240	240	-----	Psilomelane and braunite; east of	
						Kara-Dzhal Daraganda province.	
Kara-Dzhal	-----	-----	-----	-----	-----	Prof. M.A. Pavlov, Mn. Acad. & Poly.	
						Tech. Inst., Leningrad, gives	
						following data in his Metallurgy of	
						Iron, 3d ed, 1948, Akad. Sci., Moscow;	
						Analyses, Kara-Dzhal area, Ktay mine,	
Total Kazakh	-----	45	33,493	33,536	-----		

Location and deposit	Relative assurance classification					Remarks	Page 5 of 6
	A <sub>2</sub>	B	C <sub>1</sub>	Subtotal A <sub>2</sub> +B+C <sub>1</sub>	C <sub>2</sub>		
Kazakhstan, cont'd. Kara-Dzhal cont'd.						Mn 30-38 percent, Fe 12-3 percent, SiO <sub>2</sub> 5-9 percent. Klych mine; Mn 48 plus percent, Fe 0.6 percent, SiO <sub>2</sub> 13.7 percent. Kara-Dzhal mine; Mn 56.6 percent, Fe .8 percent, SiO <sub>2</sub> 2.3 percent, area not well-investigated yet.	
West Siberia							
Durnovskoye	-----	10	-----	10	-----	Near Lepinsk.	
Mazulskoye	1,032	-----	170	1,202	-----	In southwest outskirts of Achinsk. (Added note-used since 1933 at Kuznetsk. High P., T <sub>1</sub> content 0.1 percent. Cannot be used for spiegel.)	
Gavrilovskoye	-----	-----	2	2	-----	In Belovsky region.	
Novo-Firsovskoye	-----	3	-----	3	-----	Contains Co. In Beriozovsky region.	
Bastokskoye	-----	-----	-----	-----	100	In Oyratia, Mn content 48 percent (Min. Yrbk., 1934, p. 416).	
Usinskoye	-----	-----	-----	-----	-----	No data given. (Note-may be deposit comparable to Mazulskoye reported discovered in Sayan Mts 100 km. east of Stalinsk and under investigation in 1947.	
Total West Siberia	1,032	13	172	1,217	100		
Lake Baikal region							
(Olkhon), Buryat-							
Mongolian republic							
Ozerskoye	-----	-----	-----	-----		No individual data given for these deposits.	
Kutueskoye	-----	-----	-----	-----	50		

Location and deposit	Relative assurance classification				Remarks
	A <sub>2</sub>	B	C <sub>1</sub>	Subtotal A <sub>2</sub> +B+C <sub>1</sub>	
Lake Baikal region (Olkhon), Buryat- Mongolian republic cont'd. Khonkhoiskoye	-----	-----	-----	-----	(Added note. Recent press reports, 1950, refer to 2 other deposits in eastern Siberia, 1 at Tarbagatay, south of Lake Baikal near the Uda River, the other at Vandanskoe, west of the Amur River between Khabarovsk and Komsomolsk. No data was given as to size or grade. In 1930 a large manganese deposit was reported near Olga Bay, 125 miles north of Vladwistok. No recent mention in literature.)
Total Buryat- Mongolian	-----	-----	-----	-----	
				50	
Total U.S.S.R., by classes.	102,411	97,452	130,247	330,110	316,227
Total, all classes				646,337	



A<sub>2</sub>, B, and C are similar in coverage to the usual proved and probable or measured and indicated classes and that class C<sub>2</sub> refers to possible or inferred material. The predominant manganese minerals are given for each deposit with, occasionally, a notation on undesirable structure or impurities, but analyses and grades are not stated in the estimate. Locations of the more important deposits are shown on the attached map. (Figure X-6.)

Friedensburg, (45) in his review of world mineral resources, gives the manganese-ore reserves of the U.S.S.R., in millions of tons, as Nikopol, 390; Tschiaturi, 160; Orenburg (south Urals) and Mazulka (west Siberia), 70; and Labinsk, 30 — a total of 650.

## N. TURKEY

Asiatic Turkey has been a small producer of manganese since 1924, exporting a few thousand tons each year. As far as known, all of the material produced to date has been mined from open pits, usually small, and hand-sorted to the required shipping grade.

Numerous manganese deposits are known throughout Turkey, namely along the sea coast on the lower side of the Black Sea and along the Mediterranean and Aegean Seas. Kostov estimated the reserves of Turkey to be 12 million tons. In the light of more recent investigations this figure is considered to be high by possibly one order of magnitude. Recent reports through ECA (46), by C. O. Mittendorf, representative in Ankara, indicate that only three deposits in Turkey contain substantial visible ore reserves. These are:

(A) Esek Deresi, near Milas, on the southwest sea coast, where approximately 100,000 metric tons of visible ore occur. Quantitatively, this is the most important of the deposits, although, the physical and chemical qualities of the ore are unknown. This deposit is in the State of Mugla, northwest of Fethiya, which has been widely known in the past as the port of export and chrome and manganese.

(B) The Geul or Kurucular deposit, in the Province of Coruh, northeast Turkey, near the Black Sea close to the Russian border. This deposit is outstanding, qualitatively, containing 48.8 to 52.8 percent Mn, but the physical character and the amount of reserves are not known.

(C) In central-west Turkey the Gokcedag deposit, approximately 100 Km. east of Balikesir, is estimated to have a visible reserve of 20 to 70,000 metric tons, ranging in content from 25 to 50 percent manganese. The physical properties of the material are now known.

Approximately 30 other small deposits of manganese are known in Turkey but have not been active as far as is known to date.

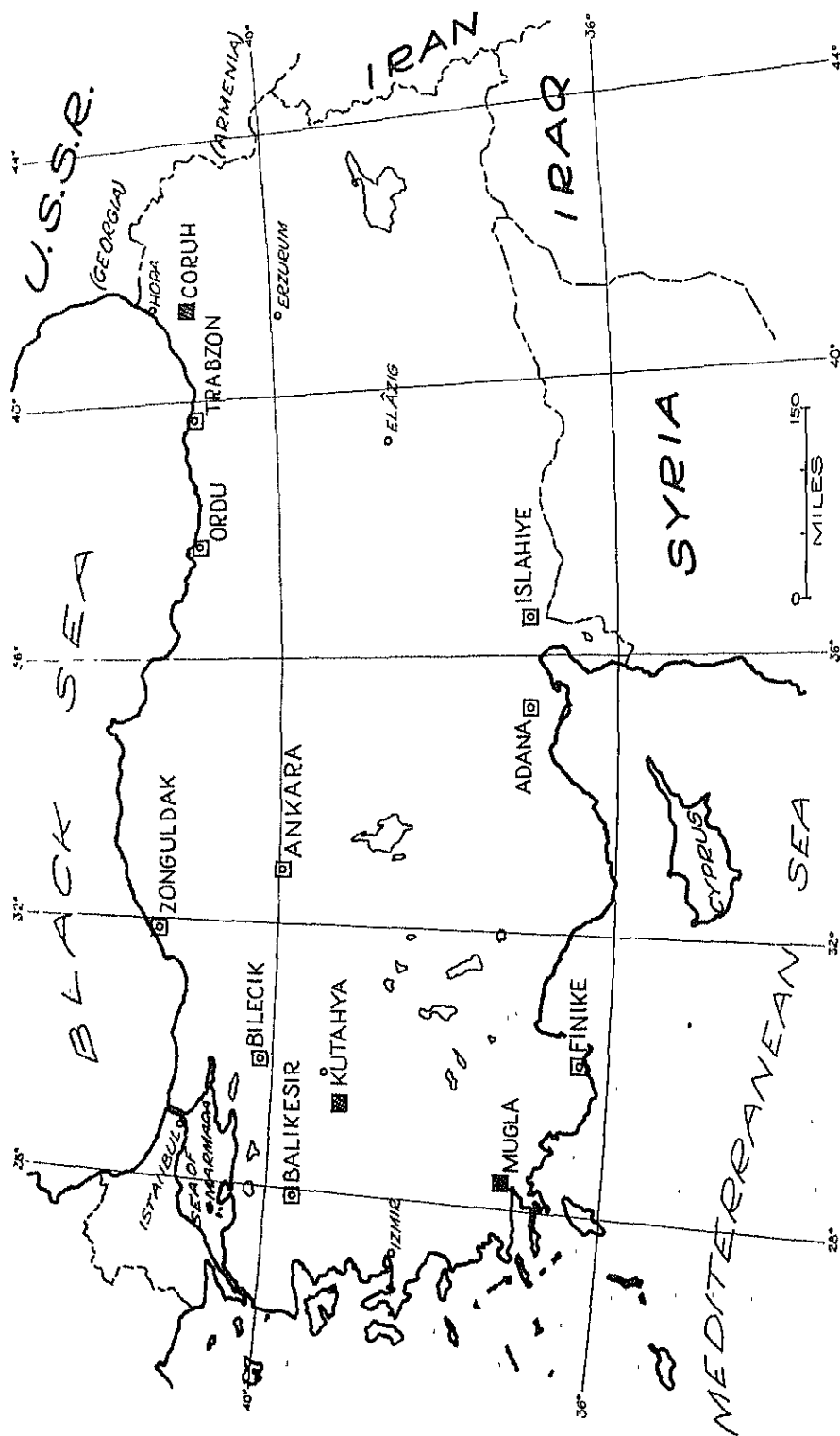


FIGURE X-6. Manganese deposits in Turkey

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## XI. EUROPE



## CHAPTER XI EUROPE

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## XI. EUROPE

### A. ALBANIA

Albania does not produce manganese ores. Occurrences of pyrolusite have been noted (1) in the Juranic schists near Munela Mountain, in Scutari prefecture.

Manganese is also known to be associated, in small amounts, with the copper pyrite ores of Kamenitza and Rehova, in Koritza prefecture.

### B. AUSTRIA

Austria has not been a producer of manganese ore since about 1930 when operations are said (2) to have been suspended because of small reserves and high cost of operations.

A considerable tonnage of manganimiferous iron ore is produced, however, and published data may refer to the estimated manganese content of these iron ores, which may contain up to 9 percent Mn.

### C. BULGARIA

Manganese mining in Bulgaria, after having been dormant since World War I, revived in 1936 to produce some 2,000 tons per year. Several manganese deposits have been noted (3) in Bulgaria, mainly near Sofia, Varna, and Jamboli. The most important is said (4) to be the State-owned deposit at Pozharovo-Kostinbrod, 11 miles west of Sofia, which consists of lenses of pyrolusite in Cretaceous limestone. The lenses, up to 14 feet in thickness, contain 30 to 45 percent manganese and may be traced along the strike for 1 mile. Mine product is stated to average 38 percent Mn with 1 percent Fe, and the capacity of the mine, which is called "Probeda," is given at 5 to 15,000 tons per year.

At Golem Rakovitsa, 25 miles east of Sofia, a bedded deposit, up to 24 feet thick, is found between folded marl layers. The average Mn content is given as 45 to 48 percent, with low Fe content. A similar deposit at Mecka, 5 miles to the east, is said to have an Mn content ranging from 20 to 60 percent. Production data are not available for either of these properties. A bedded deposit of pyrolusite and carbonate, up to 5 feet thick, in a red-marl formation is known near Panagurishte, some 38 miles northwest of Plovdiv. Data are

lacking as to grade and size.

A deposit at Bela, on the Black Sea coast, 20 miles south of Varna is mentioned (5) as having produced some 3,000 tons per year during World War I. The ore here is pyrolusite, occurring as thin lenses and as was impregnated in upper Tertiary sandstone and marl beds. These formations, up to 30 feet thick, extend some 2-1/2 miles and stand at a dip of 30° to 60°. At best, the ore constitutes 10 percent of the formation thickness and has been calcined to make a 40-percent manganese product.

Also noted are a small producer of pyrolusite at Dobra Nadejda, 2 miles northwest of Jamboli; a lenticular deposit in sedimentary formation at Nikolaevo, some 30 miles to the west; and a promising but undeveloped prospect at Koschasch, near the Turkish border, where the deposit is found in Cretaceous formations near andesite eruptives.

#### D. CYPRUS

A small, irregular manganese deposit, 7 miles from Pappos, was worked during 1940-41. It is not considered of economic importance. When examined (6) in 1943, stocks at the property consisted of some 100 tons running about 80 percent  $MnO_2$  and about 1,000 tons containing around 40 percent manganese.

#### E CZECHOSLOVAKIA

Czechoslovakia is not listed here among producers of manganese ore because the ores produced there average only 17 percent manganese and should be classed as ferruginous manganese ores. The estimated manganese content of these ores, in itself a substantial figure, may be found among published statistics on manganese and could be misleading if not explained.

Principal mines (7) (8) are at Kisovce and Svabovce, near Poprad, Slovakia, where both work the same sedimentary carbonate deposit, a flatlying bed, 1 meter thick, in Tertiary Shales. Mining is by underground methods with access through adits. This deposit has been reported by Kostov (9) to contain 4-1/2 million tons of reserves.

Another important mine is at Chvaletic, eastern Bohemia where sedimentary manganese-iron ore deposits are worked by open-pit methods. The ore is thought to be either an isomorphous mixture or intimate intergrowth of siderite and rhodochrosite. Manganese

silicate ores, rhodonite, etc., metamorphosed from carbonate, are known at Litosice and Morasice, east of Chualetice.

## F. GREECE

Manganese deposits in Greece are numerous but only partly explored. Geological reports and reserve estimates are sketchy. Some of the small deposits and rich spots have evidently been worked out. Production over the past 50 years has been intermittent, ranging at times up to 10,000 or more tons per year of grades above 30 percent manganese content. Output broke sharply in 1940, with virtually no production until 1949, when one mine was again operated. Currently ECA (10) is endeavoring to raise manganese-ore production back to former levels and anticipates that the output of battery-grade ore may reach 7,000 tons per year before long.

Deposits are of three general types: (a) Replacements in limestone, (b) replacements in serpentine schist and hornstone, and (c) secondary deposits formed by erosion of the first two types and found as flat-lying beds or as fillings in cavities, fissures, and sink-holes in limestone.

The attached map shows the location of many of the manganese deposits, mainly in Macedonia and Thrace in the north, on the Peloponnesus, and on islands off the southeast coast. Of these, the more prominent deposits are (a) northwest of Drama near the Bulgarian border and (b) on the Peloponnesus near Kalamata and Zerbissa.

The southwest part of the Peloponnesus is known to be rather extensively mangiferous (11) with outcrops traceable northward from Kalamata to Patras. (12) Typically, the deposits are small, being limited to a few hundred tons of minable ore.

The Zerbissa area has larger deposits in which pyrolusite is found in small seams in bedded schist and hornstone and as irregular impregnations and masses in limestone. The ore is mined by hand from open-cuts and adits. Battery-grade ore has been produced by hand sorting. After sorting, the lower-grade material is concentrated by gravity methods to a 56-percent product (13) which may also be battery grade.

A recent report (14) spoke of plans for rehabilitating this property. Deposits of pyrolusite at Meligula are thought to be superficial and unimportant.

The Kalamata mine, known also as Yiannitsanika, is about 3 miles from the port of Kalamata, where there are facilities for handling up to 1,000 tons of ore per month. The ore is hard, crystalline pyrolusite, low in iron but containing about 5 percent combined calcium magnesium carbonate. Reserves are thought to be of the order of 100,000 tons available for open-pit mining. It is also thought that probably one-tenth of the mine product could be sorted out as pure pyrolusite and the balance treated to meet the usual mixed ore specifications.

Deposits northwest of Drama, at Kato Nevrokopi and at Zirnovon, produced small tonnages of 44-to 52-percent manganese ore in the 1930's. These operations have been referred to as the Cynthia manganese mine. The deposits occur between limestone beds and metamorphosed schists. Mine product is hauled to the port of Kavalla by trucks and trucks.

The Tartana pyrolusite mines, in the same area, 46 km. north of Drama were reported (15) in 1927 to contain about 100,000 tons of soft, pure pyrolusite as lenses in limestone fractures, more or less normal to the bedding. Mining was by open-cut quarrying methods. Recent reports, however, do not mention the name Tartana, and it is not known whether this property is separate from the Cynthia.

Deposits on Andros Island, some 9 miles from Andros village, were opened about 1925 by Kokkinis Bros. & Dailey, consist of horizontally dipping lenses, predominantly of manganite but with pyrolusite in small areas. Silica content is understood to be about 18 percent. No proved reserves are evident.

Some attention has been given recently to a deposit on Antiparos that had not been worked since about 1910. The deposit consists of hard, compact polianite and is thought to run about 30 percent manganese in  $MnO_2$  and  $MnO$ . Reserves have been reported as of the order of 100,000 tons, but this has not been confirmed.

On the Island of Milos near Cape Vani, formerly worked by open-cut methods, a washing plant using sea water. The ore was high in manganese content. The best part of the ore was sorted out, leaving considerable residue carrying 10 to 20 percent





FIGURE XI-1. MANGANESE DEPOSITS IN GREECE

Rhodochrosite has been produced in the past on Cassandra peninsula, southeast of Salonica. Present reserves are given as 200,000 tons. The mine plant is reported (16) to have two calcining kilns. Calcined product is believed to assay 30 to 35 percent manganese content.

Ferruginous manganese ores, of 30 percent iron content with 12 to 14 percent manganese, have been mined in the past at Laurium at the end of the Attic Peninsula southeast of Athens.

Manganese occurrence have also been noted on the islands of Paros, Siphnos, Seriphos, Kimilos, Keos, and Mykonos (too siliceous).

With treatment, it is thought that run-of-mine material from most of the deposits in Greece can be beneficiated to a product containing 43 percent manganese or better.

## G. HUNGARY

Manganese deposits in Hungary, though of minor importance in the world picture, are sufficient to make Hungary independent of foreign sources as well as to supply ore from export. It is believed that recent production, some 25,000 tons per year, has for the most part, if not entirely, come from Urkut in western Hungary, about 15 miles north of the Plattensee (Lake Balaton) where production has been intermittent since discovery of the deposits about the time of World War I. A deposit at Eplenyi about 18 miles northeast of Urkut has also been developed and may have been in production at times.

Deposits (17) at Urkut are of two types: (a) At Ujakna, north of Urkut, primary bedded deposits containing psilomelane with minor amounts of pyrolusite, are found associated with the Lias limestone as two layers, about 2 and 7 feet thick, separated by 2 feet of marl, and (b) on the western slope of the Csardahegy Mountains, less than 1 mile east of Urkut, nodules, again mainly of psilomelane, occur as secondary deposits in pockets in a reddish Liassic limestone. The nodules vary from pea-size to lumps of some 200 pounds and average about 36 percent manganese content. Mining in the Urkut district was confined to the open-pit Csarlalegy operations until their abandonment in 1930, when the Ujakna deposits, estimated at that time to have reserves of some 4,000,000 tons, were developed for shallow underground operation. An ore-dressing plant of 160 tons daily capacity was built at Urkut to beneficiate the mine ore, which contained 23 percent manganese with 17 to 20 percent  $\text{Fe}_2\text{O}_3$  to a dressed product

containing 42 to 47 percent manganese and averaging 44.4 percent. Thus, approximately 2 tons of mine ore were required per ton of concentrate.

At Eplenyi the ore minerals are also psilomelane and pyrolusite associated with small amounts of manganite, braunite, and polianite and are found as nodules in a clay matrix in limestone country rock. The bed is about 3 feet thick, in places reaching a thickness of 9 feet. Reserves were estimated at about 500,000 tons in 1934. Undeveloped low-grade deposits, estimated to contain some 6 million tons of material of 8-to 20-percent manganese content are known in the Bükk Mountains area, near Miskolc, northern Hungary, about the same distance northeast of Budapest as the Urkut deposits are to the southwest. Specific locations noted are Eger and, of lesser importance, Noszvaj and Demjen. At Eger the formation is said to be some 12 feet thick, interstratified with clay, and to consist of two manganese-bearing beds, the upper 3 feet thick, the lower 4 feet thick.



FIGURE XI-2. Manganese deposits of Hungary.

#### H. ITALY

Italy is a substantial importer of manganese ores, notably from U. S. S. R., South Africa, and the Gold Coast, to satisfy requirements for domestic production of manganese ferro-alloys.

The manganese deposits of Italy are, in general, so small that they are marginal in competition with foreign ores yet essential to domestic industry.

Principal sources of high-grade manganese ore were reported (18) during World War II to be the Tre Monti and Gambatesa mines east of Genoa, with annual output of some 15,000 tons of 45-percent manganese ore, the Canneto mine to the southeast near Pisa with output of 5,000 tons of 48-percent ore, and, in the northwest, near the Swiss border, the recent Piedmont mines, Mount Alpi and Mount Pu, which produced a smaller tonnage of 45-percent ore. Pyrolusite was being mined at Bosa, Sardinia, at that time at the rate of 50 tons per month.

The Canneto mine, near Cecina southwest of Livorno, was developed in 1936 following discovery of pyrolusite deposits associated with limestone at shallow depths near Pisa. Reserves at the Canneto mine were reported (19) shortly, thereafter, as 100,000 tons of developed ore with an additional 400,000 tons probable. The developed ore averaged 25 percent manganese and 45 percent silica, consequently a treatment plant was planned.

Other deposits, said to contain 34 percent manganese, have been noted (20) in Civitavecchia province near Montecuccio, Paradiso, and Montecucchetto.

Most promising of the several deposits, at that time, were the beds of friable manganese ore, up to 3 feet thick, found interstratified in trachyte tuffs on the island of San Pietro, off the southwest coast of Sardinia. The ore, averaging 30 percent manganese content, was being concentrated in a 350 ton per day, mill near Carloforte to make a 46 percent product. It was anticipated that the output of this plant might reach 50,000 tons per year when the mines were fully developed and that Sardinia might become an exporter of 1,000 tons or more per month to the United Nations. (21)

Ferruginous manganese deposits, found as irregular masses in limestone and carrying 16 percent Mn and 34 percent Fe, are mined by cut-and-fill methods at Monte Argentario, near Grossetto, in the south of Tuscany. Output was over 17,000 tons in 1937.

On the following page is a map showing the deposits of Italy. (Figure XI-3.)

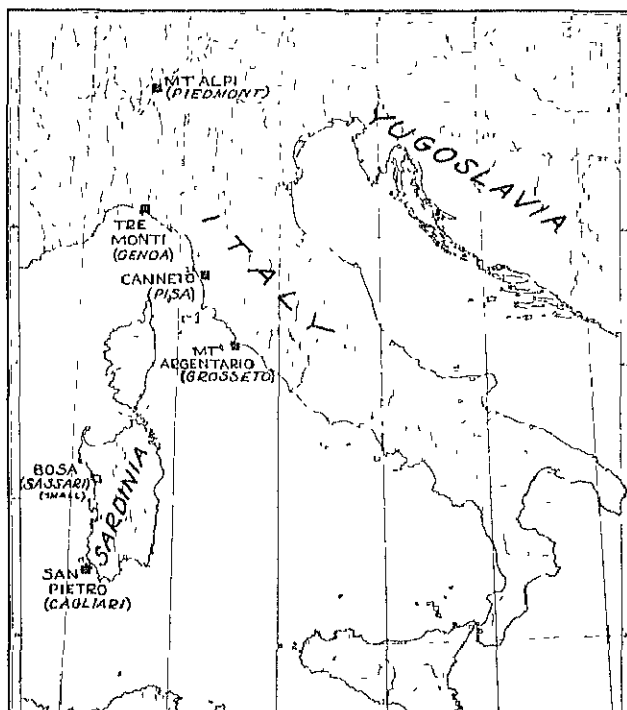


FIGURE XI-3. MANGANESE DEPOSITS OF ITALY.

## I. NORWAY

Though not a producer of manganese ore, Norway is one of the principal world exporters of ferro-alloys made by the electric furnace process; these include ferromanganese and silicomanganese. Norway has an abundance of cheap electrical power made from hydro-electric resources.

In 1939, the Foreign Minerals Quarterly issue (22) devoted to the Scandinavian countries made no reference to manganese-ore deposits in Denmark, Finland, or Norway.

A recent report, (23) however, mentions the finding of a manganese deposit at Sauda, near Stavanger, western Norway. The area is not easily accessible. The iron plant at Sauda now used South African manganese.

An earlier report (24) referred to a secondary deposit of bog ore, 2 kilometers long by 300 to 400 feet wide, at Tana, Smalfjord, assaying 13 to 40 percent manganese.

## J. POLAND

Manganese deposits in the Carpathian Mountains, southeastern Poland, though reported (25) at 10 million tons, are understood to be low in grade and inaccessible.

These may be the same deposits that were later reported (26) under development near Burkut at the southern tip of Poland.

Poland is not listed among producers of manganese ore.

## K. PORTUGAL

Portugal has a number of small manganese deposits and was an early producer before the Indian and Cancasus ores became available. The ores, however, are reported (27) as being generally friable and containing little lump or metallurgical grade without beneficiation and agglomeration, for which no plants are available. Sole producer, at present, is stated (28) to be a small mine at Anadia, 30 km. north of Coimbra, where a 42-percent grade is produced intermittently for export.

The manganiferous iron ores of the Odemira, or Thiago, district in southwest Portugal have been reported (29) to run 20 to 50 percent Fe, 2 to 35 percent Mn, 5 to 35 percent  $\text{SiO}_2$ , 0.05 to 0.35 percent P, and 0.03 to 0.25 percent Sf. Reserves were said to be of the order of 10 million tons.

## L. RUMANIA

According to Groves, (30) who quotes the Rumanian Geological Survey, manganese ore deposits occur in the following places: Eastern Carpathians, Maramuresului Mountains, Lapasului Mountains, Baia-de-Aries, Turda, Codrului Mountains, Zarandului Mountains, the Banat, Poiana Rusca, and the Southern Carpathians.

The reserves in 1938 were estimated at 9 million tons (31 & 32) and in 1943 at 7,390,000 tons. (33) In general, the ore is of inferior quality, ranging in grade from 14 to 40 percent Mn. Most of it is consumed domestically.

The major Rumanian deposits occur in Moldavia and Bucovina in the eastern Carpathians (see northeastern Rumania on index map), and the more important mines are in the communes of Jacobeni and

Vatra-Dornei. The ores occur in the crystalline schists of the Bistrita Mountains, on both banks of the Bistrita River, and in the Crystalline massif of Brosteni. The deposits are generally small pockets in strongly folded strata. Primary minerals are rhodonite and rhodochrosite; where these have been oxidized to psilomelane, etc., ore is mined. At Jacobeni, the reserves of six deposits are estimated at about 880,000 tons of manganese oxides and 200,000 of manganese silicates. At Vatra Dornei "part of the reserves" is estimated at 100,000 tons. The total reserves of the region were fixed in 1919 at about 1,000,000 tons of visible and probable ore and 250,000 tons of silicate and carbonate ore (34) and at 1,240,000 tons in 1943. Neither of these totals includes the figures for the Brosteni region, which have been estimated at as much as 5-1/2 million tons.

The Mashea deposit, in the Somes district, at the southern end of the Lapazului Mountains (north-western Rumania), was first worked during World War I, and production had continued through 1938. The deposit is 700 yards long and 6 to 40 yards wide. The primary minerals are rhodonite and rhodochrosite; the oxidized portion contains psilomelane, pyrolusite and wad, together with limonite and unaltered silicates and carbonates. In 1919 reserves were estimated at 200,000 tons. (35)

Important production has come in recent years from the deposit at Delinesti in the Banat region (southwestern Rumania). Low-grade ores consisting of psilomelane and pyrolusite in limonite occur as small bands and lenses in gneiss and mica schist. The beds are 27 meters thick. The deposit measures 7 km. by 60 to 90 meters, and had a possible reserve of 1,200,000 tons of 15 to 30 percent Mn - 10 to 25 percent Fe ore in 1930, according to Ghitulescu and Gavut. (36) Other estimates, however, are not so optimistic with regard to Delinesti. Figures as low as 200,000 tons have been quoted in table XI-1. The obvious conclusion is that not too much value can be placed upon any of these estimates.

Table XI-1, referred to in the preceding paragraph, gives a comprehensive picture of the Rumanian manganese situation. (37)

On the following page is a map showing the manganese deposits of Rumania. (Figure XI-4)

Table XI-1 RUMANIA - MANGANESE AND MANGANIFEROUS IRON-ORE DEPOSITS, DISTRIBUTION AND ESTIMATES  
OF RESERVES

OF RESERVES						
1943 Estimates of Reserves /1 (Metric tons)	Region	Judetul	Town	1931 Esti- mates of Reserves /2 (Metric tons)	Type of ore	Physiographic divisions
5,500,000	Moldavia	Neamtu	Brosteni	n. r.	n. r.	
1,240,000	Bucovina	Campulung	3/ Sarul Dornei	100,000+	100,000 oxides, silic- ates not estimated	Eastern Carpathians
			3/ Vatra Dornei	1,080,000	880,000 oxides, 200,000 silicates, 36% Mn.	
			3/ Iacobeni	4,000+	4,000 oxides, silic- ates not estimated	
			Coana	115,000	60,000 oxides, 55,000 silicates	
			Clocanesti			
--	Maramures	Maramures	Carlibaba			
			Poenile de sub Munte	n. r.	Low-grade	Maramuresului
		Satu Mare	Visaul de Sus			Mountains
			Durusa			
	Northern Transylvania	Somes	Razoare	200,000	200,000 oxides, carbon- ates, and silicates	Lapusului Mountains
			Masca			
	Southern Transylvania	Turda	Baia de Arles	n. r.	Low-grade	
			Salciua			
			Turda			
		Bihor	Vascau		Manganese oxides 29- 53% Mn.	Apuseni Mountains
			Moneasca	520,000	Iron oxides 3-17% Mn	
	Crisana	Arad	Halmagel	n. r.		
			Pernesti			
			Tarmiseti	213,000	Deposits small and spotty, 30-40% Mn	
{included with Transylvania above}	Southern Transylvania	Hunedoara	Godinesti			
			Prihodiste	n. r.	n. r.	
			Batrana	n. r.	Iron ore, 1-2.5% Mn	Pojana Rusca
200,000	Banat	Severin	Poeni			Banat
			Ohaba			
			3/ Delinesti	1,200,000	Oxides, 14% Mn, 14% Fe	
		Caras	Apaula			
			Tarnova			
			Bania Rudaria	260,000	15-30% Mn, 8-45% Fe	
		Severin	Ieselnita			
			Iablanita	40,000	15-45% Mn, 8-10% Fe	
		7,390,000	Total Rumania			

1/ Argus, Bucharest, Sept. 1, 1943.

2/ Ghitulescu, T. P., and Gavut, I., (General Review of the Iron, Chromium, Manganese, and Pyrite Deposits of Rumania). Corr. econ. roumaine, vol. 13, No. 5, Bucharest, 1931, pp. 9-17.

3/ Deposits currently being exploited.

n. r. - Not reported.





## MANGANESE DEPOSITS IN RUMANIA

BOUNDARIES CORRECTED TO 1949

FIGURE XI-4. Manganese deposits of Rumania.

### M. SPAIN

An important producer of manganese and manganiferous ores up to 1900, when output had reached the 100,000-ton-per-year level, Spain has since been a consistent producer but at a much lower rate. Until 1931 the grade of shipments was listed as 29-percent-plus manganese; since 1937 the grade has been classed as 40-percent-plus. Recent output has been about 20,000 tons per year, mostly from Huelva Province. Primarily an exporter of manganese ores until 1932, the manganese-ore industry of Spain has since declined to the point where it is in approximate balance with the ore requirements for domestic ferromanganese production, which is carried on at metallurgical plants at Corcubion, in Coruna, and at Boo, in Santander.

Many of the iron ores of Spain are manganiferous, reportedly (38) carrying 2 to 12 or more percent of manganese.

Much of the Spanish manganese ore is low in grade, with high

silica content, because of exhaustion of the high-grade deposits. Largest recent producer is said (39) to be the La Joya mine near Zalamea la Real, Huelva Province, with output of some 8,000 to 12,000 tons per year. The mine ore is beneficiated in a washing plant. Other recent producers are the Florentina mine near Calanas and the Castillo Palanco and the Nuevo Posterera near Zalamea la Real, all in Huelva Province. At the Florentina mine the ore is stated to be pyrolusite and psilomelane, analyzing 28 to 45 percent manganese and occurring as lenses interbedded with slates. In 1946, small production was noted (40) from Ciudad Real, Oviedo, Sevilla, and Burgos Provinces.

The deposits of Huelva Province have been described by Hoyer; those of Ciudad Real by Michael. The Huelva deposits, some 100 in number, are in southwest Spain near the Rio Tinto pyrite deposits on the north slope of the Sierra Morena. They are found as lenses, seldom over 500 feet long by 100 feet wide, associated with folded slates and porphyroids. Rhodochrosite (manganese carbonate) and rhodonite (manganese silicate) form the major part of the lenses in association with pyrite, garnet, and mica. At surface, the carbonate and silicate ores have been oxidized to pyrolusite and psilomelane to a depth of some 65 feet. (41) The primary carbonate ores analyze 28 to 45 percent manganese, with 3 to 7 percent iron and 5 to 15 percent silica, while the silicate ores run 39 to 45 percent in manganese with 20 to 22 percent silica.

The bedded manganese deposit of Ciudad Real province, near Val de Penas consists largely of psilomelane ranging from 40 to 60 percent manganese and averaging 43 percent. A small amount of cobalt (42) is present - 3 to 7 pounds per ton of ore. The bed is about 4 feet thick and has been mined by open-pit methods.

## N. SWEDEN

Sweden is an important world producer of ferro-manganese and silico-manganese and has long been a consistent producer of manganese ores, in annual amounts up to 25,000 tons. Average output of ore for the past 50 years is 8,800 metric tons, largely for domestic consumption.

Manganese ores are of three types: (43) (a) pyrolusite with manganite, (b) hausmannite with braunite, and (c) manganese carbonate with iron ore.

The principal deposits worked have been at Langban, in the

province of Varmland, at Spaxeryd and Hohult, in Jonkoping province, and at Bolet, Skaraborg province. The Langban mine, unique as the producer of the greatest variety of minerals in any single district in the world, has been reported (44) as the principal source of manganese in Sweden. There is, however, a somewhat larger production of man-ganiferous iron ore. The deposit at Langban is a replacement in dolo-mite containing iron ores, braunite, and hausmannite. The ore at Spaxeryd is chiefly pyrolusite found in lodges in granite.

#### O. SWITZERLAND

Some 5,000 tons of manganese ore per year were produced in Switzerland from 1941 through 1945. There has been no reported output since then. The Gonzen mine, in St. Gall Canton, a producer of both iron and manganese ores, accounted (45) for some 80 percent of the total for the 5-year period, with the balance from the Parsettens and Falotta mines in Grisons Canton. Average content of the Parset-tens ore was given as 32 to 36 percent Mn, while the Falotta ore ran 30 to 32 percent Mn.

#### P. UNITED KINGDOM

The Benallt mine, Caernarvonshire, Wales, is reported (46) to have produced some 40,000 tons of manganese ore during two years. prior to the summer of 1944. The mine was closed after 1945. Reserves are estimated at 10,000 tons in 3 deposits.

#### Q. YUGOSLAVIA

Bosnia has been the principal source of manganese ore for many years with minor occurrences noted in Dalmatia and Serbia. Extensive deposits were being developed (47,48) before World War II at Stikovo and Jasnov, some 50 km. south of Uzice. The deposit here occurs in crystalline Triassic limestone near a serpentine intrusive and is said to have a minable zone some 50 meters wide by 600 meters long. The deposit is worked as an openpit, and the ore hand-sorted to a 53-percent Mn product.

The Government-owned deposit at Cevljanovic, northeast of Sarajevo, was prominent from beginning of operations in 1880 until after World War I at which time it was a mainstay for the Central Powers. It has not been worked much recently. The ores are mainly psilomelane with pyrolusite and are considered of sedimentary origin.

They are found as lenses in argillaceous beds and associated with barite. Mining is done both by open-pit and underground methods. The ore is beneficiated by washing and sorting to a product containing 46 to 55 percent Mn.

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## XII. AFRICA



## CHAPTER XII AFRICA

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## XII. AFRICA

### A. ALGERIA

Groves (1) states that Algeria produces only some manganiferous iron ore of about 7 percent manganese content and that manganese ore exported from Algeria probably originated in French Morocco.

### B. ANGLO-EGYPTIAN SUDAN

Manganese-bearing formation has been noted (2) north of Halaib, but no estimate has been made of grade or amount.

### C. ANGOLA (3)

A belt of manganese ore is known in Angola between Galungo Alto on the northwest and Pungo Andongo on the southeast, a distance of about 100 km. Ore has been worked fairly extensively at Quicuinhe, at the northwestern end of the belt. Elsewhere it is known only from surface exposures, which generally occupy prominent features.

The ore consists of massive psilomelane, possibly with some admixture of manganite and perhaps also braunite. By oxidation it passes to concretionary pyrolusite and earthy wad.

At Quicuinhe the deposit consists of a steeply dipping, at times nearly vertical, bed having the semblance of a vein. It is irregular in form, exhibiting swellings and pinchings and numerous pinching offshoots. It strikes generally west northwest and east southeast in conformity with the enclosing country rock. It is faulted and shattered in the vicinity of the deposit but maintains, on the whole, the character of an interbedded formation. The ore is generally of good quality, running up to 50 percent manganese; it is rather high in silica, however, reaching 40 percent in places. It is also said to contain some silver. The deposit is worked underground by means of adits and crosscuts; selective mining and sorting are required to produce a marketable ore.

The deposit has been interpreted as being a regionally metamorphosed bedded formation which has experienced a good deal of alteration and reconcentration of the ore since its origin. There has been considerable redistribution of the ore and the formation of lenses and veinlike offshoots that invade the country rock. These are, however, attributable to metamorphic action and are not the result of

hydrothermal emplacement of ore minerals.

The general mode of occurrence of ore throughout the belt is similar to that at Quicuinhe, although not much geologic field investigation has been directed at it. It is felt that, in most places in the manganiferous area, deposits could be worked by open-cut methods, or by adits at the worst. There is every reason to believe that this occurrence of manganese ore has considerable potential importance.

The major concession in the area is now held by Angolan Manganese Co., which estimates, (4) perhaps optimistically, that it may soon be exporting at the rate of 6,000 tons per month. Few data are available on reserves; but, in view of the known size of the manganese belt and the sudden surge in Angola production in 1949, reserves of the order of several hundred thousand tons are expected.

#### D. BELGIAN CONGO

Manganese ores occur in the Province of Katanga in the southern part of the Belgian Congo. The known deposits are all quite near the Leokadi (Leopoldville, Katanga, and Dilolo) Railway, which connects with the Benguela Railway at Dilolo. The distance to the coast at Lobito ranges from about 1,450 km. (from the westernmost deposit) to about 1,900 km. (from the easternmost).

The most-important deposit worked to date is west-northwest of Kilwezi and just south of the railway. The Mutshatsha mine (see map), also known as the Kasekelesa mine, has been the principal source of this ore, which is high-grade lump, running over 50 percent in manganese with low iron and phosphorus but containing about 1-1/2 percent of base metals. It was reported nearing exhaustion in 1943, but ore was removed during the latter months of 1949. In 1938, however, Groves reported that the Kasekelesa deposit, west of Musonoie was estimated to contain some 850,000 tons of high-grade ore, (5).

The Mutshatsha mine was closed down from 1944 until early 1947. In 1944, the entire Congo production of approximately 3,000 tons is reported to have come from the Kisanga iron mine near Kambove. (6) The ore at this mine consists of psilomelane and other soft manganese oxides in irregular masses in dolomite and is found in steeply dipping beds. It is mined by open-cut methods. It assays about 50 percent Mn, with low Fe, and 1.5 percent phosphorus, and small amounts of base metals.



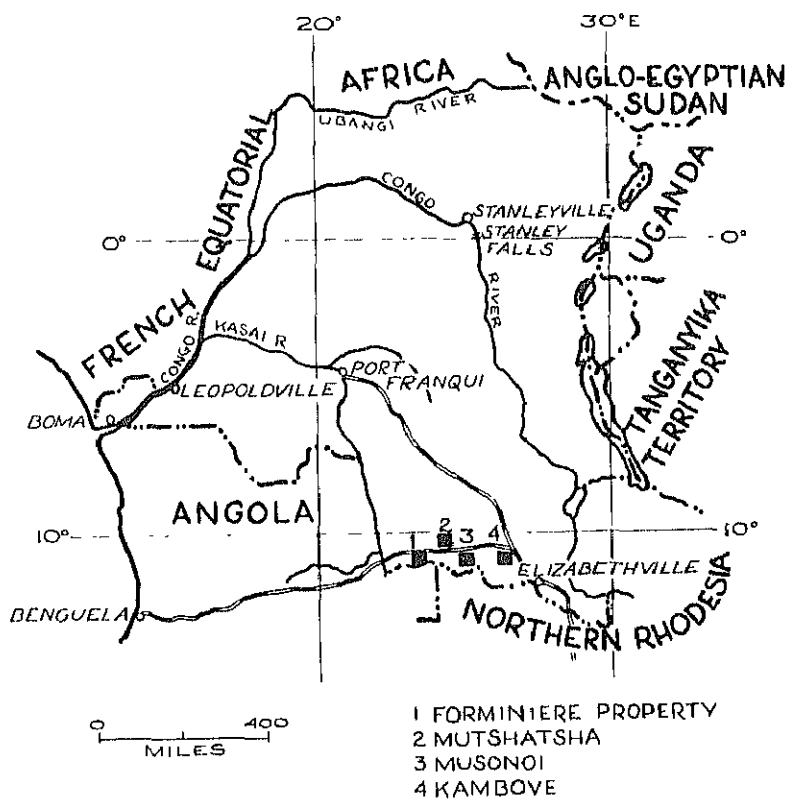
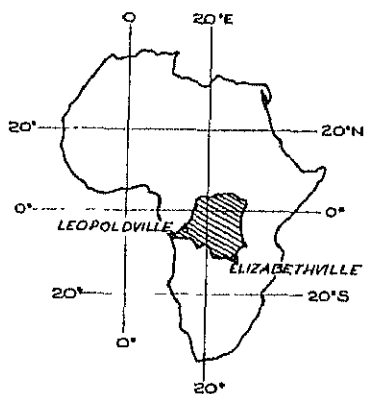


FIGURE XXI-1. Manganese deposits of the Belgian Congo



Impressive new deposits are known in the region south of Malonga. These deposits, lying between the Lukoshi and Luashi Rivers, about 50 to 60 km. south-southeast from Malonga, were discovered in 1928-30, but mining activity has not yet begun because of lack of transportation facilities. The area is one of mostly metamorphic and igneous rocks which outcrop chiefly in the valley bottoms, and sandy clay or lateritic coverings which mantle the plateaus and hilltops. Ore occurs in two manners: (a) As ledges on the surface of the ground, on hill crests--the ore is found both as float and in place; and (b) as pisolitic material, poor in outcrop, in lowlands that are swampy during the rainy season. The ore is thought to be a replacement of highly metamorphosed rocks of the "gondite" type. It is noteworthy that the apparent source rock is rich in spessartite, the manganese garnet. Polinard (7) concluded that the ore minerals are chiefly hollandite and polianite (crystalline pyrolusite). Details of the reserves are not available at present but the deposits are thought to be of the order of 1 million tons available for shallow open-pit mining and that total reserves would run considerable more, although possibly of somewhat lower average grade. The ore assays 50 percent manganese, with low iron and phosphorus. Forminiere, a Belgian Congo mining firm, is considering beginning hand-mining operations on the basis of a production of 30,000 tons a year. It is felt that mechanized mining could increase this figure to 100,000 tons or more.

Further deposits are reported to be located to the east and northeast of Dilolo (8) and west of the gold mine at Ruwe (9).

#### E. EGYPT

Egyptian manganese deposits are restricted to the Sinai Peninsula. There are several occurrences; but only one, at Um Bogma, has had commercial importance to date. The ore bodies are found along a southwest-northeast line between Um Bogma and Um Rinne (see map), a distance of about 20 km. The most important ore bodies occur at the base of the Carboniferous limestone. (10)

By usual standards, the Sinai ores should be classed as ferruginous manganese, since the manganese content is less than 35 percent and the iron content more or less parallels the manganese content. However, these ores have long been included statistically among the world's manganese ores, possibly because the manganese content occasionally reaches 35 percent.

Um Bogma is about 80 miles southeast of Suez and is connected with the Red Sea port of Abu Zenima by 11 miles of railway and 6 miles of aerial ropeway. The country is rugged and intersected by deep canyons. There is virtually no water in the mining region. The aerial haulage route covers the mountainous region to the coastal plain.



FIGURE XII-2. Manganese deposits of Egypt and Palestine.

The Um Bogma ore bodies, which yield about 200,000 tons of ore annually, (11) are horizontal, bedlike deposits. They are irregular in outline, tending to be tabular or lens-shaped, and are discontinuous and variable in composition. The principal ore bodies outcrop on the steep scarps that bound four groups of plateaulike hills known respectively as the Central, North, East, and South Hills.

The ore bed is generally 2 to 3 meters thick (12) and in places reaches 4 meters in thickness. Pyrolusite is the main ore mineral; Psilomelane is also known. Most of the ore is low-grade, averaging 28 to 32 percent Mn. Combined manganese and iron run fairly constant (about 57 percent), although there is considerable variation in the relative proportions of the two metals. Phosphorus, silica, and alumina contents are low.

In addition to the regular-grade, some chemical ore is produced analyzing 92.5 percent  $MnO_2$ .

Open-cut mining is employed where the overburden is not too thick. Underground mining is by the room-and-pillar method or by the longwall system. The extreme irregular shape of the ore bodies at times presents a mining problem, increasing the development costs. They are said (13) to end "as sharply as if cut off by knife." This is in part due to post-mineralization faulting and probably, as well, to the origin of the bodies, which are supposed to be residual deposits derived from manganiferous limestone.

#### F. ERITREA

Although known for many years, deposits of iron and manganese in the Ghedem mountains, some 10 miles southeast of Massaiva, were not investigated in sufficient detail to estimate their type or size until about 1940 when field exploration by an Italian firm with the aid of sampling by the Eritrean Bureau of Mines indicated (14) they might have commercial interest, primarily as a source of iron.

Reports indicate that there are at least 10 deposits, or outcroppings, of iron and manganese in the vicinity, the larger being on the west flank of the hills, with the smaller ones evident on the east and south slopes. Four parallel outcrops, striking east northeast - south southwest at the foot of the west flank, appear at present to be the most important of the group. Four lenses, one to each outcrop, have been noted within a strike distance of about 1 mile. These lenses, varying in width from about 6 to 30 feet, have been trenched for a total length of about 1,000 feet and have been tested to shallow depths (30 feet) by drill holes. The schist formations in the Ghedem Mountains dip westerly at  $70^\circ$  to  $80^\circ$ . One drill hole has confirmed one of the lenses to a depth of some 150 feet, and from this it has been suggested that possibly all of the lenses are parts of the same body. (15)

The deposits are stated to be limonite and hematite, richly manganiferous in places. Sample reports indicate that the manganiferous portions contain about 25 to 48 percent manganese with iron content ranging from 2 to 25 percent. Medium analyses might be around 35 to 40 percent manganese, with 2 to 7 percent iron.

Preliminary estimates have been of the order of 15,000 to 20,000 tons of manganese ore available in the four bodies tested, with iron-ore reserves ranging upward from 250,000 tons.

The attached sketch shows the location of the deposits and the area covered by a concession granted in 1940.

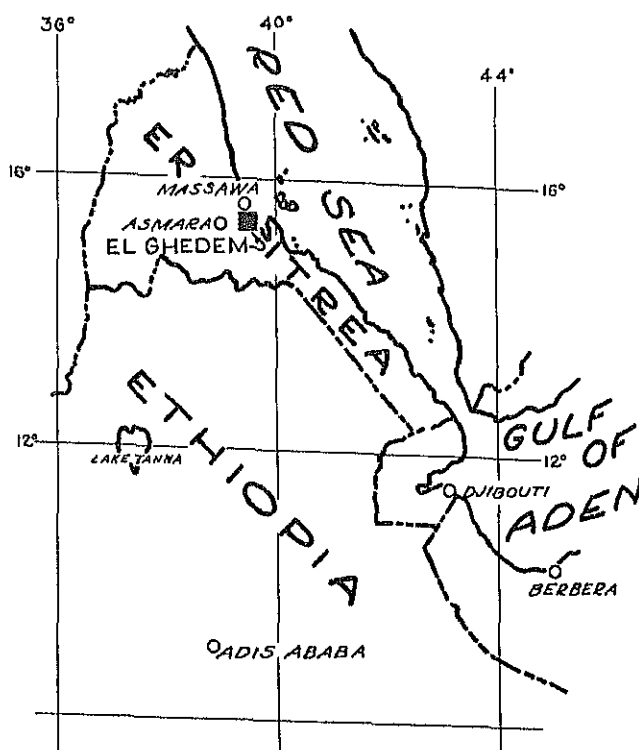


FIGURE XII-3. Manganese deposits of Eritrea.

#### G. FRENCH MOROCCO

Manganese ores are found and mined in two distinct regions of French Morocco - in the eastern part, near the Algerian border, and in the southern part, on the south flank of the Atlas Mountains. The eastern region includes the Taourirt district, some 15 km. south of Oujda, and the Bou-Arfa district, an additional 230 km. directly

south. The southern region includes the Imini district, 150 km. southeast of Marrakech, the Tiouine district, 15 km. south of Imini, and the undeveloped Tasdremt deposit near the town of d'Aoulouz. Imini and Bou-Arfa are the largest producers.

Reserves are variously given at upward of 30,000,000 tons for both regions, of which 10,000,000 tons are proved ore. Geology and mining seem to present no particular problems. These obstacles, however, are apparent: (a) Lead content of the ore is high, (b) many of the ores are friable, and (c) transportation to port is especially costly for the southern district.

#### Eastern Region

The ores in the region, largely pyrolusite, are found as boulders, veins, lenses, and thin beds in Permo-Triassic shales in two rather widely separated areas.

In the Taourirt district (also called d'El Aioun), the deposits are small and are aligned for 100 kilometers south of the Fez-Oujda Railway. (16) In 1948 two mines, the Narquechoum and the Tanourat, were producing hand-cobbed lump ore of 45 to 50-percent manganese content at the rate of 800 tons per month. The product is sent by rail to the port of Nemours. Known reserves were given at 100,000 to 200,000 tons.

The Bou-Arfa district, principal mining center of this region, is in the extreme eastern part of the Atlas Mountains. Deposits are lens-shaped beds; some lenses contain over 100,000 tons of ore. The quality of the ore varies greatly. At the Sin Beida mine, which is stated to have the largest reserves, the ore is poor in quality and friable, containing about 30 percent manganese and 15 percent iron, but is free of impurities, notably lead and silica. About one third of the mine output is beneficiated to a 36-percent grade and agglomerated at the mine plant. Output in 1948 was given at 4,500 tons per month of metallurgical-grade, plus 300 tons of chemical-grade, presumably hand-cobbed.

A recent reserve estimate places the probable ore in the Bou-Arfa mine at 1,500,000 tons; earlier figures (17) gave 2,000,000 metric tons for the main deposit with possible reserves for the Eastern Morocco given at 20,000,000 tons. In 1938, the Bou-Arfa reserves were stated (18) as "tens of millions of tons."

The deposits at Imini, in the southern region discovered in 1918, are now considered the largest in Morocco. Reserves have recently been given as 6,000,000 tons of proved (19) ore. The deposits occur as three mineralized beds, flat-lying, 2/10 to 1 meter thick, in Cretaceous formations. The mineralized ore, including some discontinuities and irregularities, extends 20 km. east-west. At St. Bou Tazouet, in the center of the area, the mineralization forms a single bed 1 meter thick, 100 to 500 meters wide, and 5 to 6 km. long, of approximately 51-percent manganese content. Mining is by underground room-and-pillar methods, with access through adits. The roof is strong. In 1948 production was 8 to 9,000 tons per month of metallurgical-grade ore plus 1,000 tons of hand-cobbed chemical grade. The purer ore is found as inclusions within the metallurgical-grade lumps. Mine output is hauled by truck (the fleet consists of 150 Mack trucks of 10-ton capacity) convoy to Marrakech, thence by rail to Casablanca, where there is a sintering plant of 100,000 tons per year capacity.

In the Tiouine district, 15 km. south of Imini, the ore occurs as lenticular beds in Cambrian strata, also as hard, siliceous mineral, containing about 46 percent manganese. The mineralized zone is said to be 12 km. long. Open-pit mining is being carried out at three locations, and the product is hand-cobbed to a 48-percent grade. Production in 1948 was 3,000 tons per month. Reserves were given at 1,000,000 tons.

The Tasdremt deposit, as yet undeveloped, is near the town of d'Aoulouz. Geology is similar to Imini - interstratified beds at the base of the formation in a Cretaceous series. The mineral runs 42 percent manganese but contains 5 to 7 percent lead. Reserves are estimated at 1,000,000 tons.

The Sarhro-Ougmar mine, some 270 km. southward from Marrakech, is said to have over 200,000 tons of certain reserves. Production to date has been small - about 4,000 tons in 1949. A specification for the product indicates that it contains over 58 percent Mn, 8 percent  $\text{SiO}_2$ , less than 2 percent Fe, and 1 percent P. Transport is by truck to Marrakech.

Ore reserves of the major deposits and production of manganese ore by individual companies in recent years have been repeated on the following page as follows:

Table XII-1. ORE RESERVES OF PRINCIPAL MINES

Mine	Metric tons	Mn content, percent
Bou Arfa	1,500,000	
Imini - Metallurgical ore	5,400,000	50-54
- Chemical ore	600,000	80-90 (MnO <sub>2</sub> )
Tiouine	1,000,000	46-48

Table XII-2. PRODUCTION OF MANGANESE ORE BY COMPANIES  
IN FRENCH MOROCCO, (1938-49) IN METRIC TONS

	1938	1947	1948	1949
<b>Metallurgical ore:</b>				
Societe des Mines de Bou-Arfa	41,069	59,771	65,307	66,074
Compagnie de Tifnout Tiranimine	866	-	34,314	34,598
Societe Anonyme Cherifienne d'Etudes Minieres au Maroc	15,278	31,813	84,361	98,644
Societe de Prospection et d'Etudes Minieres au Maroc	17,036	-	-	-
Omnium Nord-Africain	3,925	7,589	-	-
Societe Intermines Narguechoum	335	2,698	2,843	6,172
Tanourart	-	1,432	2,912	-
Omnium de Gerance Industrielle et Miniere	-	-	4,592	9,713
Societe Miniere Sargho Ougmar	-	-	1,087	3,401
Societe Miniere des Ait-Saoun	-	-	-	520
Craig-Stanton & Co., Inc.	-	-	-	1,580
Societe Cherifienne des Mines	-	-	-	1,175
	<u>78,509</u>	<u>103,303</u>	<u>195,416</u>	<u>221,877</u>
<b>Chemical ore:</b>				
Societe des Mines de Bou-Arfa	1,669	1,940	1,344	1,152
Societe An. Cherifienne d'Etudes Minieres	6,370	4,173	17,652	10,796
	<u>8,039</u>	<u>6,113</u>	<u>18,996</u>	<u>11,948</u>



# MANGANESE DEPOSITS FRENCH MOROCCO

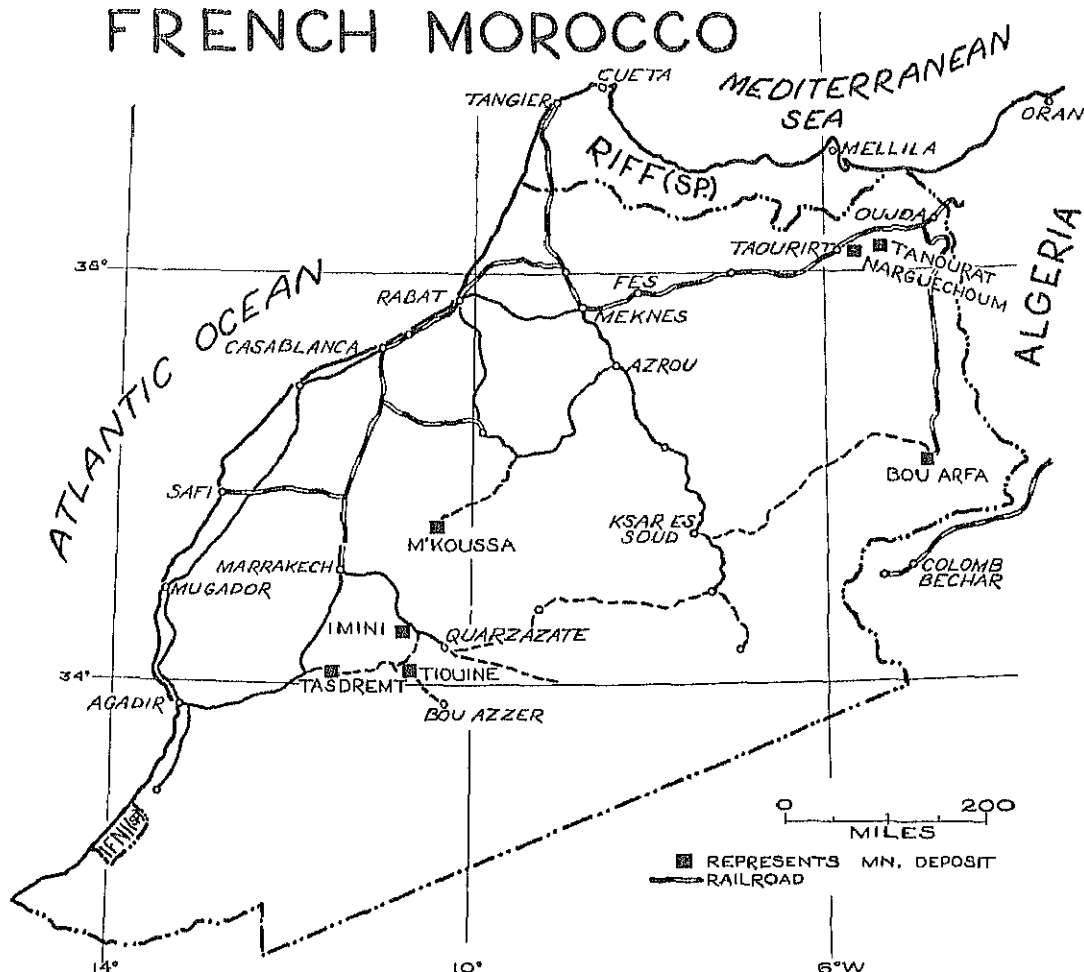


FIGURE XII-4. Manganese deposits of French Morocco.

## H. GOLD COAST

The Nsuta mine, on the Sekondi-Kumasi Railway 35 miles from the port of Sekondi, is the only important producing mine in the Gold Coast. It is, however, the world's largest single manganese mine.

There are two types of ore occurrence (21): (a) Detrital and (b) lenticular, bedded ore bodies that have been folded and faulted and altered somewhat by weathering. The latter outcrops along a ridge for 2.5 miles. According to Smith, (22) the entire ridge is said to be rich enough to put through the washing plant.

The detrital materials extend to depths of 40 feet, and the ore

Table XII-1. ORE RESERVES OF PRINCIPAL MINES

Mine	Metric tons	Mn content, percent
Bou Arfa	1,500,000	
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Omnium Nord-Africain	3,925	7,589	-	-
Societe Intermines Narguechoum	335	2,698	2,843	6,172
Tanourart	-	1,432	2,912	-
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Societe Miniere Sargho Ougmar	-	-	1,087	3,401
Societe Miniere des Ait-Saoun	-	-	-	520
Craig-Stanton & Co., Inc.	-	-	-	1,580
Societe Cherifienne des Mines	-	-	-	1,175
	78,509	103,303	195,416	221,877
<b>Chemical ore:</b>				
Societe des Mines de Bou-Arfa	1,669	1,940	1,344	1,152
Societe An. Cherifienne d'Etudes Minieres	6,370	4,173	17,652	10,796
	8,039	6,113	18,996	11,948



bodies proper vary considerably in length up to 1,000 feet and in thickness up to 100 feet. (23)

Ore minerals are mainly psilomelane, pyrolusite, and "component 3, "whose exact name and composition is unknown but is presumed to be  $2 \text{Mn}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ . (24) This is a similar formula to that of manganite ( $\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ). The average analysis of ore shipments to 1925 was: Mn, 52 percent; Fe, 4.6 percent;  $\text{SiO}_2$ , 4.0 percent; P, 0.11 percent. Concentrates amount to 75 percent of the original volume of material handled, averaging 49 to 55 percent Mn.

The ore was formerly supposed to have formed by leaching of manganese from manganiferous phyllites and redeposition in cleavage cracks. Service (25) has offered the alternative theory that the ores were original sedimentary deposits, like those at Nikopol, which have undergone slight metamorphism and enrichment in subsequent ages of time. This seems in keeping with fact that the structure of the ore bodies themselves is conformable with that of the enclosing - in other words, the ore formation was evidently not imposed on a pre-existing structure.

The Dixcove deposits (26) (Axim district, Western Province) are located about 35 miles due south of Nsuta. The mine is known as the Yakau, or Yakau-Himakron-Asani, manganese concession. Production from 1941 to 1946 was about 9,000 tons of metallurgical-grade and a small amount of battery-grade ore. There has been no production since 1946. Mining methods were largely manual in open cuts.

Reserves at Nsuta are estimated at over 10,000,000 tons of proved ore only. (27) Estimates are not available for other Gold Coast deposits.

According to Dunn, (28) four grades of ore are shipped from the Gold Coast. These are shown in Table XII-3.

Table XII-3. GRADES OF ORE SHIPPED FROM THE GOLD COAST (IN PERCENT)

	A	B	C	D
Mn .....	61.65	56.90	52.77	46.08
Fe .....	.10	1.60	4.00	7.70
P .....	.126	.11	.11	.14
$\text{SiO}_2$ .....	.30	2.45	4.60	5.55

Grade A is chemical ore; grades B and C constitute the bulk of the tonnage exported.

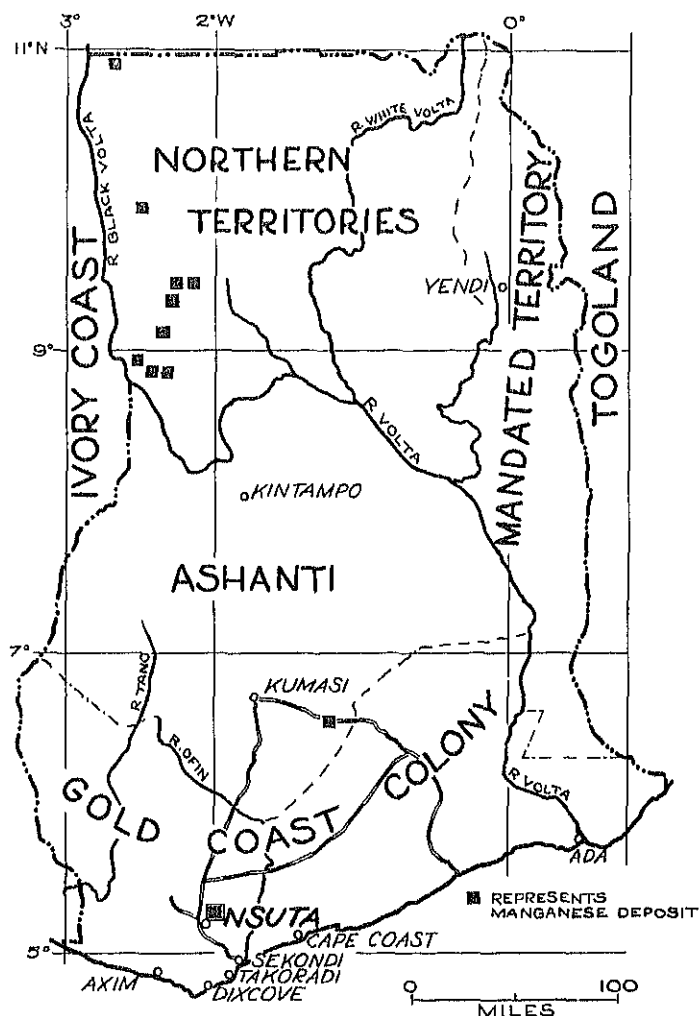
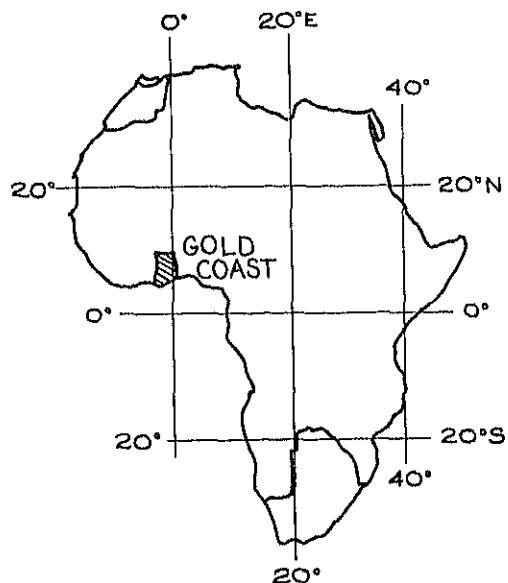


FIGURE XII-5. Manganese deposits of the Gold Coast, Africa



## I. MADAGASCAR

A small tonnage of manganese dioxide, presumably for chemical was produced (29) in 1926.

## J. NORTHERN RHODESIA

Manganese associated with iron has been noted (30) at numerous localities in northwestern Rhodesia, frequently as residual deposits. Most of the occurrences appear to be low-grade and not extensive. The Chowa deposit, some 40 miles north of Broken Hill, consisting of a nearly vertical seam of ore containing up to 40 percent manganese, appears to have been the most consistent source of production since it was first opened about 1934. Several thousand tons of outcrop ore were shipped from the Tubemba deposit nearby. In 1931 nearly 900 tons of manganese ore were mined for experimental purposes from a deposit at Luano East, a few miles east of Nchanga, in the copper belt.

## K. SIERRA LEONE

It was reported in 1929 (31) that several uneconomic occurrences of manganese oxides had been found in the Senbehum and Gbangbama districts, Southern Province of Sierra Leone. It was thought the deposits were the result of weathering of granulites and gneisses rich in manganese garnet with some graphite.

## L. UNION OF SOUTH AFRICA

The major source of manganese ore in South Africa is the Postmasburg district, 108 miles west northwest of Kimberley (131 miles by rail) and 739 miles from the east seacoast at Durban. The deposits were discovered in 1922, and the first shipment of ore (32) was made in November 1929.

The original discovery disclosed that ore was traceable for about 40 miles along the Gamagara ridge. Subsequent investigation led to discovery of additional deposits in the neighboring Klipfontein Hills. These have since come to be known as the western and eastern belts, respectively.

The typical development of the western belt ores is a bedded deposit, generally at the contact between the underlying Campbell Rand dolomite and overlying shales and other rocks. In general, the ore conforms with the bedding of the enclosing sediments, but it is not

necessarily confined to a single horizon. It seems to be more or less restricted to pockets in the dolomite.

In the eastern belt, the ore occurs as disconnected masses varying greatly in size and shape and scattered irregularly through a cherty breccia. The irregularity in all directions makes estimation or reserves hazardous.

The tonnage in the western belt is considerably greater than that in the eastern belt. Smith (33) reported in 1929 that Hall estimated reserves of 80,000,000 tons within one 6-mile stretch and that other engineers had estimated reserves for the entire field at 500,000,000 tons.

The ore is of good quality. It is hard, so that little of it is lost during handling and transit. It is dry, so that there is negligible disintegration during storage. Analyses from throughout the district run 56.0 to 60.0 percent combined Fe and Mn and only 0.02 to 0.15 percent P. Silica is the chief impurity from a metallurgical standpoint, and it is usually less than 8.0 percent. The eastern ore generally assays higher than the western, but it is much more expensive to mine.

There are two types of ores - Massive and crystalline. The former consists of psilomelane and is dark-gray, steel-gray, or black; it is structureless and hard and has a specific gravity of 4.66; it is sometimes banded, reflecting its mode of emplacement. The latter is made up of psilomelane in braunite and occurs as aggregates ranging in coarseness from mere specks up to well-developed crystals; it is harder than the massive variety and has a specific gravity of 4.7.

The ore outcrops widely and is not known to persist too much at depth. This mode of occurrence permits low-cost open-cut mining, which is almost a necessity in view of the long haul to the port of Durban.

As to origin, Nel (34) quotes A. L. Hall as follows: "He regards the deposits as 'neither of direct igneous nor of metamorphic origin due to the intrusion of large masses of eruptive rock,' but that, as far as one can judge at present, the ore is sedimentary in origin, and due to replacement of argillaceous (clayey) material through the circulation of manganese-bearing solutions, rather than as a result reached already during the period of deposition." Nel, himself concludes that the ore was formed by metasomatic replacement (or simply, replacement) as a result of downward percolating meteoric waters which contained manganese in solution. Just where these

raters picked up their content of manganese he was at a loss to say. He surmised that it might have been leached out of the Campbell Rand dolomite.

Other occurrences of Mn ore in South Africa bear brief mention. There are several low-grade, noncommercial deposits in southwest Cape Provinces. Deposits in the Krugersdorp district are fairly high grade but have been worked mostly for local consumption. Other deposits are found at Piet Retief, Waterberg, Pretoria, and Natal.

#### Postmasburg

According to Dunn, five grades of ore are shipped from Postmasburg. (35)

Table XII-4. ANALYSES OF ORE SHIPPED FROM POSTMASBURG (IN PERCENT)

No.	I.		II.		III.		IV.		V.	
	Fe	Mn	Fe	Mn	Fe	Mn	Fe	Mn	Fe	Mn
1	52.21	50.38	48.95	47.22	45.93	43.28	42.97	40.14	36.68	34.39
2	8.67	10.14	10.02	11.92	12.42	15.33	16.03	19.51	18.75	21.30
3	3.90	3.90	3.40	2.29	2.87	2.77	2.45	2.78	2.80	3.21
4	.049	.049	.045	.035	.044	.043	.04	.06	.039	.034

#### M. SOUTH-WEST AFRICA

Discovery of promising manganese deposits by South African Minerals Corporation, about 100 miles by road from Okahandja, South-West Africa, has recently been reported (36). The deposits are understood to lie north and west of the rail point of Okahandja near Otjiworongo. The size of the deposits will not be known until the area has been explored more thoroughly.

On the following page is a map showing the manganese area in South-West Africa.



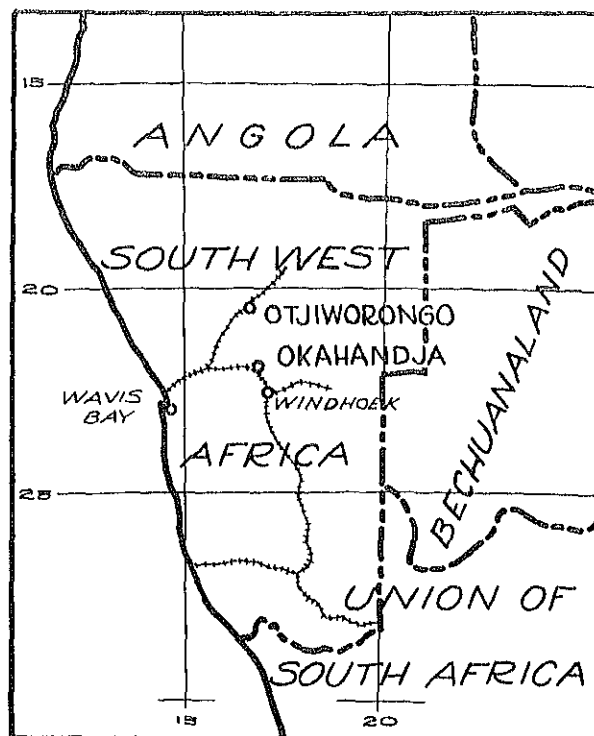


FIGURE XII-6. Manganese area in South-West Africa.

#### N. TUNISIA

Although there are numerous occurrences of manganese in Tunisia, the deposits have been considered (37) of minor importance.

Marginal deposits of manganese were worked at Thuburnic, in northwest Tunisia, near the Algerian border, from 1915 to 1929 at a rate up to 2,000 tons. The ore was reported to contain 30 percent Mn and 27 percent Fe. At times, the shipping grade was listed at 42 percent. In 1938 the Thuburnic mine was the only producer in the country. (38).

A deposit at Batoum, near Gafsa, was developed about 1929 and was claimed (39) to have high-grade ore with reserves of 400,000 tons.

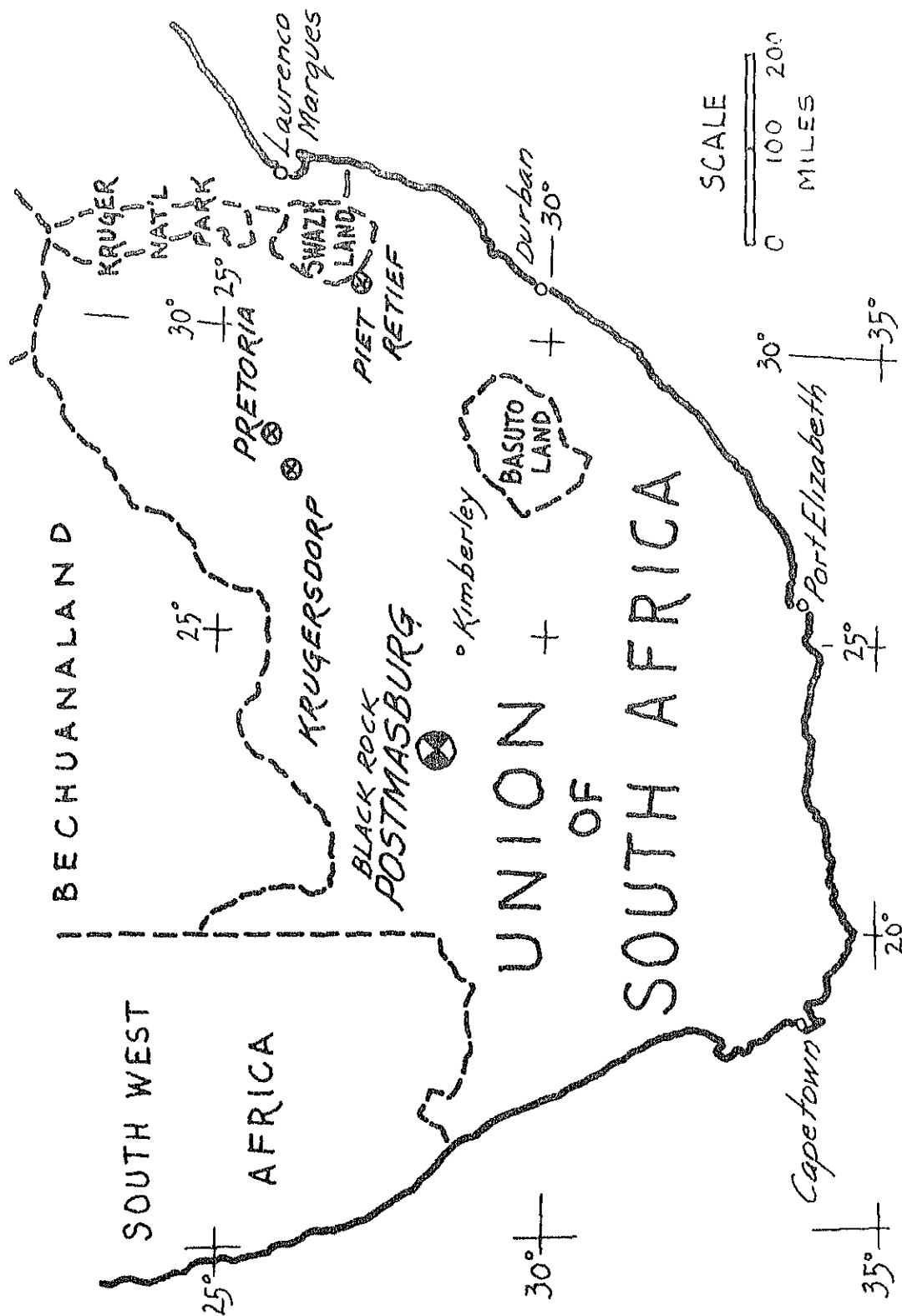


FIGURE XII-7. Manganese Deposits in the Union of South Africa

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### XIII. OCEANIA



## CHAPTER XIII OCEANIA

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### XIII. OCEANIA

#### A. AUSTRALIA

Australia has been a small producer of manganese ore, mainly for local consumption, for some 40 years. Peak output in war periods has been less than 15,000 tons per year. In addition to using local ores, which in some instances have come from remote localities, Australia has generally been a net importer of manganese ore and ferromanganese to supply its iron and steel plants.

Numerous manganese deposits, generally very small, are noted (1) throughout the Commonwealth. The map, (figure XIII-1) shows many of these locations. Best-known, perhaps, are the deposits at Pernatty Lagoon and Blinman in South Australia, which have been leading producers in recent years. Ore in sight at Pernatty Lagoon was reported largely depleted by the end of 1943, while reserves at Blinman were estimated at 7,000 tons in 1942. Largest-known reserves are in remote desert country near Horseshoe, Western Australia, where two deposits, outcropping over considerable lengths have been reported (2,3) on. The southern deposits, fairly well explored, has been estimated to contain at least 230,000 tons of black manganese oxide, predominantly psilomelane, running 42 to 50 percent Mn, 6 to 14 percent Fe, and 1 to 2 percent  $\text{SiO}_2$ . The northern deposit, after preliminary inspection, was estimated at 190,000 tons containing 47 to 52 percent Mn, 3 to 9 percent Fe, and less than 1 percent  $\text{SiO}_2$ .

Manganiferous iron ore, of 8 to 11 percent average manganese content, is produced in appreciable tonnages from large hematite deposits at Iron Monarch, South Australia. Exceptionally, the manganese content of these ores may be as high as 38 percent.

The Electrolytic Zinc Co., at Risdon, Tasmamia, produces some 3,000 tons per year of crude manganese dioxide as a byproduct from the chemical treatment of zinc concentrates from Broken Hill. Rhodochrosite and rhodonite are found in the gangue minerals associated with these lead-silver-zinc ores.

Residual deposits containing psilomelane or pyrolusite are the principal sources in Australia of ferro-grade ores containing over 40 percent manganese. There are also a few sedimentary deposits and lode occurrences.

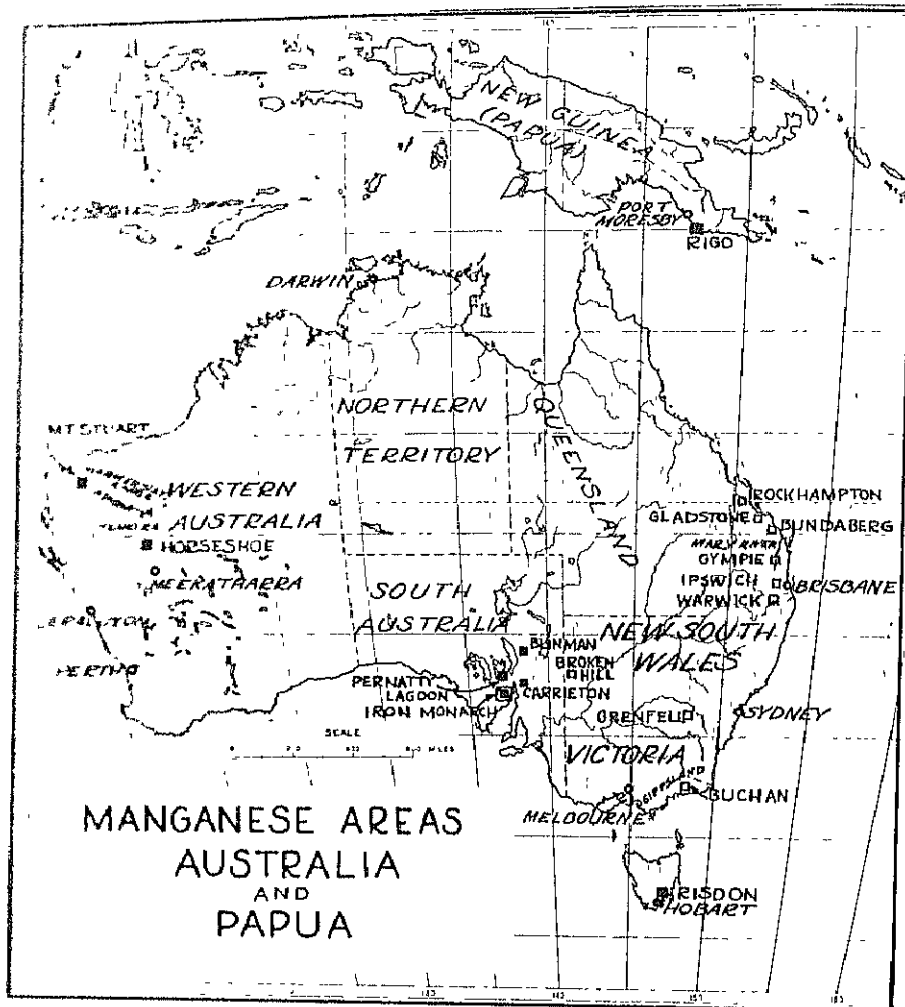


FIGURE XIII-1. Manganese deposits of Australia and Papua.

#### B. NEW CALEDONIA

Prior to 1922, when Australia imposed an import duty of 20 percent on manganese ore, there had been a small production in New Caledonia for several years. Production was again reported in 1948.

Recently, manganese-bearing beds have been located (4) between Bourail and Voh, on the west coast. Metal content, however, is reported as very irregular with silica frequently present.

Two concessions, the Luce 14 and the Michel, in the Poya region began production late in 1940.

### C. NEW ZEALAND

Small tonnages of manganese ore have come in recent years from a deposit near Otau, 35 miles south of Auckland on the west coast of North Island. This deposit has been described (5) as a vertical lode some 10 feet thick and estimated to contain some 16,000 tons of readily available high-grade material close to the outcrop.

### D. PAPUA (NEW GUINEA)

Papua (New Guinea) is a source of small amounts of chemical-grade pyrolusite from deposits at Rigo on the coast southeast of Port Moresby. Reserves are stated to be small. A reported (6) analysis of this ore shows 84.4 percent  $\text{MnO}_2$  content.

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#### XIV. SOURCES AND RECOVERY OF SECONDARY MANGANESE



## HAPTER XIV. SOURCES AND RECOVERY OF SECONDARY MANGANESE

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#### XIV. SOURCES AND RECOVERY OF SECONDARY MANGANESE

In the uses of manganese the term "consumption" must be qualified in order to consider secondary sources. Consumption, in the general sense, refers to the amount of manganese used in a process; however, a certain amount of the manganese actually enters the product and may be considered consumed or used up, while other amounts are either only used as a catalyst as in some chemical applications, or discarded as a waste upon completion of the production process.

##### A. MANGANESE IN STEEL SCRAP

In the steel industry, part of the manganese used enters the finished steel as an alloy and may be considered as actually lost, since it does not become available until the steel has been finally returned to the open-hearth furnace as scrap. The manganese content of the scrap charged into the open hearth takes very little if any part in the furnace reactions since, most of it is soaked up into the slag almost immediately. Under present practice the manganese from the scrap metal is considered a loss, since it performs no useful function before it enters the slag, and after entering the slag it is discarded as a waste.

##### B. MANGANESE IN PIG IRON

As noted above, a certain amount of manganese enters the steel-makers' slag from the scrap metal introduced into the furnace. The second source of manganese in the slag is carried into the furnace by the pig iron. This manganese enters the slag along with that from the scrap metal.

##### C. SLAGS AS A SOURCE OF MANGANESE

Slags are an important part of steelmaking, since they protect the steel from contact with the flame in the course of the process and provide a sort of selective blotter into which impurities from the steel bath may be absorbed. In general, slag will contain the following:

SiO <sub>2</sub>	CaO
Al <sub>2</sub> O <sub>3</sub>	MgO
P <sub>2</sub> O <sub>5</sub>	FeO
S	Fe <sub>2</sub> O <sub>3</sub>
SO <sub>2</sub>	MnO

The steel industry in the United States has found that it is commercially practical to recharge about 40 to 45 percent of this slag into the blast furnace to reclaim the  $\text{FeO}$  and  $\text{Fe}_2\text{O}_3$ . This reclaiming process is necessary owing to the fact that all the phosphorus in the slag, as well as that ordinarily present in the rest of the blast-furnace burden, is smelted directly into the metal.

Phosphorus in minute amounts makes steel brittle at low temperatures, and, since it is difficult to remove phosphorus from steel, every effort is made to keep the element within very low limits in the metal from the smelting process on to the finished product.

By charging all the open-hearth slag into the blast furnace, a phosphorus cycle would be introduced that would soon wipe out the commercial advantages gained in reclaiming the iron.

The manganese in the slag charged to the blast furnace largely enters the pig iron or the blast-furnace slag, although a certain amount may be volatilized and lost out the blast-furnace stack.

Manganese that enters the steel process at the blast-furnace generally must come from the iron ore; therefore, only those ores that contain manganese will provide manganese-bearing slags. In the United States such ores are found in the Great Lakes region and thus limit consideration of manganese reclaimed from slag to those areas using lake ores.

#### D. AVAILABILITY OF MANGANESE-BEARING SLAGS

Under assumption of a steel output of 100,000,000 tons a year, the production of slag will be close to 18,000,000 tons a year on an industry average of about 18 tons of slag per 100 tons of steel. Since approximately 75 percent of our steel is produced from Great Lake iron ores, then slags containing manganese in large enough quantities to be of interest will run about 13,500,000 tons. The present industry practice of recharging slag into the blast furnace reduces this amount

another 45 percent making available about 7,400,000 of manganese-bearing slag that is considered waste and is dumped. Blast-furnace open-hearth slag, and other mill refuse is dumped into one pile, resulting in dilution of the manganese content of the material to 1-1/2 percent or less. Bethlehem Steel Co. has installed a system of differential dumping in which the slags from the open-hearth furnaces are separated; it has been estimated that this accumulation of slag averages about 8 percent manganese.



## E. POSSIBILITY OF COMMERCIAL RECLAMATION OF MANGANESE

The Iron and Steel Institute and the Federal Bureau of Mines are cooperating on a project to reclaim the manganese contained in open-hearth slag. Insofar as is known, this process would result in reclaiming 85 percent and would produce an artificial ore that could be used in the conventional way for producing ferromanganese and other manganese alloys. If this process proves successful, and indications are that it may, it will become possible to make available 500,000 tons of manganese metal a year from the slag dumps of the steel industry. It should be remembered that this process is only possible where manganese-bearing iron ores or some sweetened iron ores are used in the blast furnace.

## F. TENTATIVE PROCESS

As of this time, investigations of the Bureau and the Institute indicate a two-step process. First the slag would be smelted down in a blast furnace. The blast-furnace product would be introduced into a Bessemer-type furnace, wherein differential oxidation would be practiced. Silicon would be oxidized first and then the manganese. All manganese could not be oxidized without some of the phosphorus oxidizing also. To combat this situation, an overlapping rather than a batch process is used. After the first charge is in the converter, the blow is started and stopped before all the manganese is oxidized and before the phosphorus begins to oxidize. The slag containing the oxidized Mn is removed while the metal remains in the furnace. A fresh charge is added and the blow begun again. Part way through the oxidizing process the blow is stopped, and the metal is removed while the slag is left behind. This process is repeated over and over.







## XV. ORE RECOVERY



## CHAPTER XV. ORE RECOVERY

### Tables

World production of manganese ore by countries, 1900-49	
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Africa								
Year	Canada	Costa Rica	French Morocco	Port. W. Afr.	North Rhod.	Tunisia	Union So. Afr.	Total
1950	NA j	---	37,265	---	---	NA j	790,937	---
1949	---	---	33,830	18,600	4,039	---	655,175	1,803,097
1948	3	---	14,412	400	3,961	---	276,393	1,207,938
1947	204 a	---	14,290	700	---	25	288,213	1,019,558
1946	---	---	37,990	1,900	1,420	---	237,897	1,089,046
1945	---	---	14,458	---	1,965	---	114,546	876,590
1944	---	---	27,550	2,000	5,127	313	106,883	624,385
1943	44 a	---	19,010	4,000	4,787	---	219,122	835,771
1942	395 a	---	14,273	NA j	6,211	102	394,445	1,173,200
1941	---	---	30,722	---	4,775	106	445,893	1,033,084
1940	138	---	14,713	---	3,550	---	412,071	1,046,713
1939	359 a	---	15,389 i	---	3,018	50	419,697 i	1,006,167
1938	---	304	6,597	---	2,779	NA	551,739	1,210,556
1937	77 a	100	6,460	---	2,379	---	631,194	1,459,979
1936	200 a	---	9,360	---	3,071	---	258,244	852,368
1935	91 a	---	4,865	---	4,040	---	95,450	649,229
1934	---	---	7,300	---	2,074	---	65,497	446,869
1933	---	---	4,500	---	5,453	---	21,229	300,764
1932	---	---	3,980	---	---	---	---	56,498
1931	176	---	1,502	---	1,491	---	101,899 i	444,060
1930	497	---	6,200	---	887	---	147,321	740,975
1929	273	---	3,150	---	1,879 i	200 i	9,349	681,787
1928	349	---	2,300	---	1,821	2,200	---	494,054
1927	---	---	2,696 c	---	705	2,056	1,300	573,077
1926	---	---	306 i	---	---	1,550	835	502,420
1925	---	---	679	---	---	1,655	471	446,741
1924	530	---	---	---	---	3,220	930	414,191
1923	181	---	---	---	---	1,153	592	276,655
1922	66	---	---	---	---	180	157	171,654
1921	62	589 c	---	---	---	1,500 i	287	66,056
1920	589	3,253 c	4,375	---	---	1,300	61	130,176
1919	600	10,148 c	4,000	---	---	1,313	78	89,888
1918	399	10,168 c	---	---	---	830	834	59,939
1917	143	8,080 c	---	---	---	5,970	---	37,606
1916	868	1,475 c	---	---	---	2,027	---	6,353
1915	182	---	---	---	---	1,460	---	1,460
1914	25	---	---	---	---	---	---	---
1913	---	---	---	---	---	---	---	---
1912	68	---	---	---	---	---	---	---
1911	5	---	---	---	---	---	118	118
1910	22 n	---	---	---	---	---	52	52
1909	---	---	---	---	---	---	---	---
1908	---	---	---	---	---	---	---	---
1907	---	---	---	---	---	---	---	---
1906	---	---	---	---	---	---	---	---
1905	---	---	---	---	---	---	---	---
1904	---	---	---	---	---	---	---	---
1903	---	---	---	---	---	---	---	---
1902	---	---	---	---	---	---	---	---
1901	---	---	---	---	---	---	---	---
1900	---	---	---	---	---	---	---	---
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Table XV-1. WORLD PRODUCTION OF MANGAL

North America							
	Cuba	Mexico	Puerto Rico	United States	Total	Argentina	Brazil
	78,903 c	32,400 d	---	121,974 a		NA j	162,60
	72,503	54,671 b	---	114,427 a	231,601	NA j	149,89
	29,073	53,800	---	118,931 a	201,807	NA j	141,25
	50,397	31,400	---	119,409 a	201,410	NA j	142,09
	130,764	25,000	---	130,303 a	286,067	NA j	149,14
	101,243	51,959	---	165,412 a	415,614	4,272 a	244,64
	257,864 h	80,671	---	224,632 a	563,167	3,155 a	146,98
	311,214 h	70,503	---	186,129 a	567,890	1,645 a	275,55
	249,255	40,000	---	173,043 a	462,693	1,424 a	306,24
	251,385	7,500	---	79,646 a	338,531	1,476 a	437,40
	119,652	4,038	---	40,767 a	164,795	710 a	313,39
	102,415	---	---	29,777 a	132,551	651 a	257,752
	123,444	---	1,039 c	25,727 a	150,914	437 a	306,025
	131,299	---	2,381 c	40,887 a	174,744	606 a	262,409
	43,471	3,377 i	3,058 c	32,635	87,741	443 a	156,201
	35,269	3,217	3,412 c	26,852 q	68,841	439 a	41,767
	63,064	664	1,738 c	26,940 q	97,406	583 a	7,527
	27,625	573	1,664	19,453 q	49,315	410	24,893
	9,800	700 p	2,339	18,062	30,901	252	20,300
	96	731	2,412 i	39,872	43,287	221	147,349
	762	732	2,577	68,111	72,679	239	206,831
	972	650	2,353	61,348	65,596	208	316,172
	2,440 i	661	1,547	47,612	52,609	141	359,651
	812	861	1,650 i	45,459	48,782	230	273,494
	21,091	3,299	1,440	47,000	79,830	140	260,536
	51,638	3,333	4,260	99,902	159,133	---	331,827
	25,310	1,800	4,698	57,422	89,760	---	159,229
	19,636	2,246	2,799	32,006	57,274	---	235,831
	4,351	---	NA j	13,619	18,036	---	340,706
	2,930	---	NA j	13,748	17,713	---	275,694
	2,482	1,137	---	95,935	103,564	---	453,737
	35,837 1b	2,794	NA j	55,839	105,270	2,342	205,725
	64,306 b	2,878	1,372 c	310,778	415,597	863	393,388
	45,225 b	73	1,208 c	131,427	191,441	6,706	532,855
	31,054 b	---	749 c	31,978	76,790	---	503,130
	5,223 b	---	---	9,767	15,172	---	288,671
	---	---	---	2,677	2,702	---	183,630
	---	---	---	4,113	4,113	---	122,300
	---	---	---	1,691	1,759	---	154,879
	---	---	---	2,496	2,501	---	173,921
	2	---	---	2,294	2,318	---	253,968
	---	---	---	1,569	1,569	---	240,788
	---	---	---	6,243	6,243	---	166,132
	---	---	---	5,694	5,694	---	236,791
	---	---	---	7,032	7,032	---	121,338
	---	---	---	4,184	4,184	---	224,390
	---	---	---	3,179	3,179	---	207,540
	---	---	---	2,870	2,870	---	161,935
	---	---	---	7,597	7,597	---	157,303
	---	---	---	12,188	12,188	---	100,419
	---	---	---	11,960	11,960	---	108,352
	36-50+	41-45+	48-51+	35+		35-38+	38-50+
	36-48+	40+	48-58+				
	36-44+		35:				

36-50+  
36-48+  
35-44+41-45+  
40+48-51+  
48-58+  
35:

35+

35-38 +

38-50+

Africa

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				Oceania				
	Austria	Belgi <sup>a</sup>	Total	Australia	New Caledonia	New Zealand	Papua	Total
1950	---	--- j	1,619,753	14,689 uu	1,842	NA j	NA j	16,173
1949	---	---	1,898,851	13,694 e	2,100	310	69	4,861
1948	---	---	1,984,570	2,657	1,671	533	NA j	1,887
1947	---	---	1,825,117	1,804	---	---	83	1,859
1946	---	---	2,348,573	1,407	---	408	44	1,174
1945	---	---	597,489	1,000	---	---	174	2,177
1944	---	--- A j	1,211,502	2,001	---	---	176	7,234
1943	---	--- A j	2,014,716	6,351	---	518	365	11,100
1942	---	--- A j	2,530,093	10,422	---	326	352	15,196
1941	---	--- nn	2,925,726	13,824	---	964	408	13,432
1940	---	--- A j	115,603	12,238	---	996	198	704
1939	---	--- 5	2,424,117	155	---	494	55	694
1938	---	--- 5	2,882,619	603	---	91	---	1,166
1937	---	--- 5	3,099,610	1,161	---	5	---	73
1936	---	--- 5	2,429,301	73	---	---	---	150
1935	---	--- 5	1,852,755	150	---	---	---	107
1934	---	--- 5	1,046,311	107	---	---	---	151
1933	---	--- 5	845,548	151	---	---	---	128
1932	---	--- 5	927,206	128	---	---	---	13
1931	---	--- 1	1,524,686	13	---	---	---	129
1930	---	--- 5	1,285,667	127	---	2	---	318
1929	---	--- 5	767,616	318	---	---	---	170
1928	---	--- 5	949,488	170	---	---	---	1,647
1927	---	--- 1	1,131,946	1,512	130	5	---	1,414
1926	---	--- 1	759,550	1,414	---	---	---	1,193
1925	---	--- 5	500,205	1,183	10	---	---	4,937
1924	---	--- 5	303,175	4,838	93	6	---	2,937
1923	---	--- 3	144,296	2,865	64	8	---	4,406
1922	---	--- 2	71,452	3,323	1,083	---	---	10,265
1921	---	--- 5	187,223	6,065	4,200	---	---	5,353
1920	---	--- 7	225,445	3,109	2,244	---	---	7,358
1919	5,267	--- A	595,465	5,049	2,309	---	---	290
1918	180 f	2,64	486,177	9,034	900	---	---	1,292
1917	NA	2,02	571,545	290	---	---	---	1,292
1916	NA	3,84	622,534	1,292	---	---	---	556
1915	11,926	56 f	967,635	556	---	---	---	26
1914	13,808	---	1,337,825	26	---	---	---	27
1913	16,540	---	1,089,576	27	---	---	---	333
1912	12,472	---	729,183	333	---	---	---	1,170
1911	15,955	---	889,370	1,170	---	---	---	833
1910	15,695	---	893,106	828	---	5	---	619
1909	16,657	7,13	536,415	613	---	6	---	1,403
1908	16,800	---	1,198,078	1,403	---	---	---	---
1907	13,400 g	---	555,463	---	---	---	---	---
1906	13,800 g	---	536,455	---	---	---	---	---
1905	10,200 g	---	528,601	---	---	---	---	---
1904	6,200 g	---	633,019	---	---	---	---	---
1903	5,600 g	---	627,140	---	---	---	---	---
1902	7,800 g	---	986,836	---	---	---	---	---
1901	8,800 g	---	---	---	---	---	---	---
1900	---	---	---	---	---	---	---	---

3+  
5+

45-56+

52+

Table XV-1.

WORLD PRODUCTION OF MANGANESE

						Europe /2		
	Bulgaria	France	Germany	Greece	Hungary	Italy	Portugal	Rum.
	---	NA	NA J	NA J	NA J	16,208	798	65,
	---	385	NA J	1,150	---	24,219	508	47,
	---	---	NA J	NA J	---	24,689	220 k	18,
	---	---	89,000 s	---	33,470	26,530	2,444	37,
	---	---	35,000 s	15	14,780	8,400	5,932	18,
	NA J	---	19,000 s	---	10,000 e	3,297	8,114	37,
	NA J	---	NA J	---	25,000 e	23,909	9,210	29,
	NA J	---	985	290	33,580	45,070	12,611	15,
	NA J	---	2,100	43	31,880	59,971	6,820	34,
	NA J	---	2,319	180	26,380	59,773	1,815	---
	2,600	---	964	350	24,830	50,986	1,059	---
	---	---	386	11,178 i	---	44,986	353	41,
	1,987	---	163	7,075	22,221	48,282	1,008	60,
	3,000	---	226	6,952	25,088	33,532	317	50,
	1,500	---	242	1,680	27,228	24,132	290	33,
	---	---	224	423	6,291	9,127	158	19,
	---	---	515	1,206	10	6,941	295	12,
	---	---	563	1,628	6,232	4,524	26	2,
	---	---	12	745	1,497	378	---	5,
	---	---	---	356	1,132 i	6,421 i	---	18,
	---	1,000	2,349	655	9,090	10,633	---	33,
	---	1,095	475	1,600	19,044	9,917	---	35,
	---	---	210	1,080	22,167	10,274	---	31,
	7	2,710	30	8,283	17,272	9,764	491	10,
	490	2,625	25	6,348	9,909	14,010	---	8,
	565	4,002	144	4,303	3,100	14,984	11 c	5,
	300	5,000	3,554	5,726	1,217	12,189	125 c	6,
	---	5,993	10,245	---	403	9,605	13 c	12,
	---	5,224	5,532	1,300	---	4,529	239	5,
	---	3,519	3,385	---	---	4,558	353 i	3,
	---	10,302	7,270	---	---	13,740	925	3,
	---	7,016	11,475	---	100	30,841 i	193	2,
	---	9,871	13,567	5,126	NA J	31,896	NA	---
	---	11,589	16,700	---	90,269	24,532	---	---
	---	10,807	4,000	3,599	NA J	18,147	---	---
	---	10,324	500	407	11,709	12,577	---	---
	---	6,393	165	1,000	14,413	1,649	---	---
	---	7,732	760	558	19,006	1,622	---	---
	---	5,576	92,500 t	7,717	10,833	2,641	---	---
	---	6,000	87,300	733	14,756	3,516	---	---
	---	8,000	80,564	40	13,271	4,200	---	---
	---	9,400	77,182	5,374	11,921	4,700	---	---
	---	15,866	67,696	10,750	10,577	2,750	---	---
	---	18,200	73,100 g	11,100	8,200 g	---	---	---
	---	11,200	51,900 g	10,000	10,900 g	---	---	---
	---	6,800	51,000 g	8,200	9,900 g	---	---	---
	---	11,300	52,900 g	7,400	11,500 g	---	---	---
	---	11,600	48,000 g	9,300	5,300 g	---	---	---
	---	12,500	49,800 g	15,000	7,200 g	---	---	---
	---	22,300	56,700 g	18,100	4,600 g	---	---	---
	---	29,000	59,200 g	8,000	5,700 g	---	---	---
30-45		30+	30+	60-62 30+	35-48+ 30+	34-37 30-50 18-45	35-45 38-70	30-36 42+

						Oceania					
Spain	Sweden	Switzerland	U.S.S.R.	United Kingdom	Yugoslavia	Total	Australia	New Caledonia	New Zealand	Papua	Total
17,000 d	NA j	---	2,000,000 d	---	NA j	---	14,689 un	1,842	NA j	NA j	16,
17,691	10,800 d	---	1,500,000 d	---	---	1,619,753	13,694 e	2,100	310	69	4,
18,525	8,417	---	1,800,000 d	---	---	1,898,851	2,657	1,671	533	NA j	1,
22,429	10,697	---	1,800,000 d	---	---	1,984,570	1,804	---	---	83	1,
29,589	12,594	NA j	1,700,000 d	---	---	1,825,117	1,407	---	408	44	1,
24,889	18,036	2,757	2,251,000 d	11,480	---	2,348,573	1,000	---	---	174	1,
30,426	24,276	5,778	461,000 d	17,890	---	597,489	2,001	---	---	176	2,
26,150	26,703	8,138	1,000,000 d	20,558	NA j	1,211,502	6,351	---	518	365	7,
21,268	24,242	5,772	1,823,000 dx	10,599	NA j	2,014,716	10,422	---	326	352	11,
9,968	13,928	1,755	2,393,000	1,219	NA j	2,530,093	13,824	---	964	408	15,
5,865	4,600	NA j	2,800,000	914	NA j	2,925,726	12,238	---	996	198	13,
4,711	5,934	NA j	NA d	---	5,655	115,603	155	---	494	55	---
1,319	5,347	NA j	2,272,800 j	---	3,759	2,424,117	603	---	91	---	---
490	5,845	---	2,752,000	---	4,420	2,882,619	1,161	---	5	---	1,
---	5,943	---	3,002,000	---	2,739	3,099,610	73	---	---	---	---
1,260 i	6,495	---	2,384,600	---	928	2,429,301	150	---	---	---	---
3,796	5,832	---	1,821,000	---	1,103	1,852,755	107	---	---	---	---
2,834	5,895	---	1,021,300	---	535	1,046,311	151	---	---	---	---
2,591	3,014	---	832,100	---	160	845,548	128	---	---	---	---
17,916 i	4,140 i	---	876,000	---	2,454 i	927,206	13	---	---	---	---
16,819	4,907	---	1,444,166 y	---	1,539	1,524,686	127	---	2	---	---
17,872	13,674	---	1,183,880 y	---	3,072	1,285,667	318	---	---	---	---
13,704	12,617	---	673,398 y	239	2,660	767,616	170	---	---	---	---
36,870	16,823	---	843,850 y	1,048	1,971	949,488	1,512	130	5	---	---
44,947	15,258	---	1,028,607 y	130	1,244	1,131,946	1,414	---	---	---	---
36,072	10,941	---	676,502 y	842	2,716	759,550	1,183	10	---	---	---
20,840	10,881	---	426,825 y	2,496	4,570	500,205	4,838	93	6	---	---
28,615	5,045	---	223,549 y	2,053	5,143	303,175	2,865	64	8	---	---
25,455	4,510	---	90,739 y	254	1,122	144,296	3,323	1,083	---	---	---
20,098	6,253	---	28,819 c	522	910	71,452	6,065	4,200	---	---	---
21,256	14,960	---	96,992 z	13,082	5,327	187,223	3,109	2,244	---	---	---
66,685	12,400	---	76,419	12,272	NA	225,445	5,049	2,309	---	---	---
77,714	16,648	---	419,994	17,736	NA	595,465	9,034	900	---	---	---
57,474	20,027	---	204,614 v	10,101	48,851	1,024,177	290	---	---	---	---
14,178	9,048	---	480,000 g	5,222	22,674	---	---	---	---	---	---
14,328	7,733	---	537,394 f	4,714	10,422	---	---	---	---	---	---
13,155	3,724	---	905,716 f	3,492	4,120 f	---	---	---	---	---	---
21,594	4,001	---	1,254,732 f	5,480	5,800	---	---	---	---	---	---
17,401	5,164	---	926,385	4,237	4,650	---	---	---	---	---	---
5,608	5,433	---	581,215	5,067	3,600	---	---	---	---	---	---
8,607	5,811	---	731,427	5,555	4,000	---	---	---	---	---	---
7,827	5,272	---	738,610 w	2,812	5,692	---	---	---	---	---	---
16,946	4,668	---	362,303 w	6,409	7,083	---	---	---	---	---	---
41,500 g	4,300 g	---	1,003,528 w	---	7,000 g	---	---	---	---	---	---
62,800 g	2,700 g	---	1,018,961 w	---	7,600 g	---	---	---	---	---	---
26,000 g	2,000 g	---	433,663 w	---	4,100 g	---	---	---	---	---	---
18,700 g	2,300 g	---	421,055 w	---	1,100 g	---	---	---	---	---	---
26,200 g	2,200 g	---	415,301 w	---	4,500 g	---	---	---	---	---	---
46,100 g	2,800 g	---	488,219 w	---	5,800 g	---	---	---	---	---	---
60,300 g	2,800 g	---	448,240 w	---	6,300 g	---	---	---	---	---	---
112,900 g	2,700 g	---	752,636 w	---	7,900 g	---	---	---	---	---	---
40+	30+		41-48+	30+	32-38+						
31-34	35-45+				42-45+						
29+											





Year	Burma	China Footnotes
1950	NA J	NA its not available.
1949	NA J	NA
1948	NA J	22,000 Production from minor miscellaneous countries not listed:
1947	NA J	20,000 43-17c; 1942-600c; 1940-383; 1939-596; 1938-176; 1937-817;
1946	NA J	9,600 26-39; 1923-406; 1921-384; 1920-168; 1919-22; 1918-5,825;
1945	762 d	16,400 17-5,285; 1916-10,666.
1944	762 d	9,880
1943	762 d	14,839 Production from minor miscellaneous countries not listed:
1942	762 d	500 19-32; 1918-123; 1910-12,200; 1908-7,579; 1907-14,350.
1941	NA J	500
1940	---	3,370 Production from minor miscellaneous countries not listed:
		43-2; 1941-2,300; 1940-3,270; 1930-2,320; 1937-1;
1939	---	1,170 36-61; 1935-46; 1934-17; 1929-3,300; 1927-16.
1938	---	2,458
1937	---	79,187 ipments.
1936	---	43,400
1935	---	31,400 ports to U. S. x. Excludes Ukraine.
1934	---	2,629
1933	---	10,250 ports general. y Year end September 30.
1932	---	21,561
1931	---	31,850 timate. z Include Georgia.
1930	---	70,722 rtially estimated. mn Croatia only.
1929	---	61,219
1928	---	63,600 perial Institute. pp Export to Japan.
1927	---	71,331
1926	---	764 muaire statistique. qq Revised.
1925	---	439
1924	---	38,538 y weight. rr Minerals Resources,
1923	---	27,672 1919, pt. 1, p. 120.
1922	---	19,230 ade change.
1921	---	25,627 ss Year end March 31.
1920	---	25,323 timate included in total. tt Mines over 375 tons
		only.
1919	---	13,100 rtial year. see below.
1918	---	13,100
1917	---	13,100 mplete. uu January, September 30.
1916	---	12,900
1915	---	1,500 via Scotia. vv Excludes South Australia.
1914	---	1,500
1913	---	1,500 proximate.
1912	---	1,500
1911	---	1,500 cept fluxing ore.
1910	---	1,500
		Order, A.I.M.E., Journal, vol. 56, p. 57.
1909	---	1,524
1908	---	17,100 ench zone only.
1907	---	17,100
1906	---	17,100 rmany Empire prior to 1913.
1905	---	17,100
1904	---	17,100 ar ending 3/31.
1903	---	17,100
1902	---	13,000 orgia only.
1901	---	18,500
1900	---	25,700 neral Resources, 1919, pt. 1, p. 115.

35+

41+  
45-46  
50-55

WORLD PRODUCTION OF MANGANESE ORE BY COUNTRIES, 1900-19

ASIA /3					
British India	(Goa) Portuguese India	China	Indonesia	Japan	Korea
672,163 c	20,144	---	---	134,066	---
61,033	11,197 c	NA j	---	99,997	---
176,270	4,728 c	---	---	48,091	---
452,274	100 c	---	---	29,398	---
256,275	NA j	---	---	29,394	---
213,963	---	---	7,112 d	85,700 sb	---
176,924	---	7,719	7,112 d	400,679	32,
134,922	---	1,452	7,112 d	342,804	---
760,423	680	1,440	7,112 d	254,254	---
796,555	8,111	1,040	13,880	195,546	---
12,864	6,525	669	11,569	162,947	---
---	8,204	2,440	12,074	NA j1	---
---	9,478	2,214	9,687	80,000 d	---
---	4,077	5,287	11,083	70,000 d	---
---	2,662	3,430	8,619	67,753	---
---	4,064	1,568	12,353	71,659	---
---	3,800	---	11,635	57,165	---
---	1,600	---	10,463	43,535	---
---	3,573	---	8,287	26,242	---
---	3,547	---	14,541 1	12,849 1	---
---	5,476	---	16,690	19,588	---
---	5,092	---	20,892	18,446	---
---	6,654	---	24,452	17,693	---
---	2,414	---	18,503	27,560	---
---	3,089 1	---	11,393	15,209	---
---	NA j	---	10,997	12,040	---
---	NA j	---	8,482	7,505	---
---	NA j	---	5,243	5,494	---
---	NA j	---	3,233	4,440	---
---	---	---	2,093	3,881	---
---	---	---	4,179	5,474	---
---	---	---	2,915	22,877 1t	---
---	---	---	1,450	56,991	---
---	---	---	---	51,374	---
---	---	---	---	49,310	---
---	---	---	---	25,871	---
---	---	---	---	17,067	---
---	---	---	---	18,259	---
---	---	---	---	12,052	---
---	---	---	---	9,769	---
---	---	---	---	11,300	---
---	---	---	---	8,849	---
---	---	---	1,200	11,131	---
---	---	---	---	18,700	---
---	---	---	---	12,800	---
---	---	---	---	14,000	---
---	---	---	---	4,300	---
---	---	---	---	5,600	---
---	---	---	---	10,900	---
---	---	---	---	16,300	---
---	---	---	---	15,200	---
47-52+	42-50+	47-50+	50-55	32-40	---
---	42-46+	---	45-56	39-51	---
---	---	---	---	50+	---





Table XV-2. PRINCIPAL WORLD PRODUCERS OF MANGANESE ORE

Approximate Recent Production Rates	
Countries	Recent Rate (Approx. Av. M. T.)
U.S.S.R.	2,000,000
Gold Coast	700,000
India	400,000
Union of South Africa	300,000
Brazil	200,000
U.S.A.	150,000
French Morocco	100,000 +
Cuba	?
Mexico	50,000
Japan	50,000
Philippine	?
Germany (Fr. Zone)	50,000
Indonesia	40,000
Rumania	30,000
Hungary	25,000 +
Spain	25,000
Chile	20,000 +
Italy	25,000
China	20,000
Sweden	20,000
Belgian Congo	15,000
United Kingdom	15,000 ?
Portugal	5,000
Switzerland	5,000
Turkey	5,000
North Rhodesia	4,000
Argentina	3,000
Indo China	2,000 +
Malaya	2,000
Portuguese West Africa	2,000
Total Approximate	4,213,000

Table XV-3. UNITED STATES-IMPORTS FOR CONSUMPTION OF MANGANESE ORE,  
BY COUNTRY OF ORIGIN, 1944-51, GROSS WEIGHT, LONG TONS

Page 1 of 2

Year	Total	Br. India	U.S.S.R.	Gold Coast	Brazil
1934	341,339	20,550	124,836	73,656	55,834
1935	383,500	56,594	153,200	95,134	29,527
1936	613,362	126,913	289,867	241,593	110,018
1937	911,919	70,380	383,949	254,547	77,987
1938	483,586	25,480	166,042	126,857	29,698
1939	627,129	89,545	135,243	242,923	42,713
1940	1,282,079	189,473	311,748	246,983	168,241
1941	1,530,876	386,908	29,183	198,907	315,937
1942	1,413,414	536,392	15,865	168,961	291,490
1943	1,349,669	413,340	4,065	193,726	333,389
1944	1,174,711	309,664	-	142,841	176,249
1945	1,170,844	187,940	135,130	186,339	216,317
1946	1,352,271	286,857	216,000	249,690	76,799
1947	1,158,921	254,049	258,014	194,033	140,896
1948	1,315,583	281,070	342,962	193,896	143,285
1949	1,271,289	318,895	134,824	251,633	179,972
1950	1,925,148	642,505	65,583	378,105	136,343
1951	1,902,859	616,892	2,586	360,326	97,624
1952					
1953					
1954					
1955					

Source: Minerals Yearbook. Bureau of Mines, U.S. Department of Interior.

Table XV-3. UNITED STATES-IMPORTS FOR CONSUMPTION OF MANGANESE ORE,  
BY COUNTRY OF ORIGIN, 1934-51, GROSS WEIGHT, LONG TONS

Page 2 of 2

Year	Union of So. Africa	Cuba	Chile	Mexico	Philippine Islands	Other
1934	-	63,743	1,133		--	1,587
1935	-	43,955	3,442		500	1,148
1936	99	37,876	3,828		--	3,168
1937	209	122,937	398		--	1,512
1938	-	131,422	-		4,002	85
1939	3,401	105,936	49		6,966	353
1940	177,739	130,646	7,849	447	43,515	5,438
1941	273,749	243,405	16,344	941	57,048	8,454
1942	209,103	139,514	3,985	31,723	--	16,381
1943	113,982	189,089	14,585	53,984	--	33,509
1944	36,927	417,017	5,365	71,604	--	15,044
1945	55,340	262,118	81,548	46,112	--	-
1946	217,559	141,727	128,123	35,500	--	16
1947	172,206	50,972	37,570	45,437	2,121	3,623
1948	253,014	29,324	9,199	47,995	9,036	5,802
1949	246,046	54,296	13,154	47,827	12,629	12,013
1950	510,025	96,917	7,761	34,546	6,073	47,310
1951	423,985	147,086	23,843	99,927	12,301	118,289
1952						
1953						
1954						
1955						

Source: Minerals Yearbook. Bureau of Mines, U.S. Department of Interior

General imports of manganese ore (35% Mn or more) into the United States in the first half of 1950, in short tons:

Table XV-4. MANGANESE-ORE IMPORTS

Source	Battery Grade		Other		Totals	
	Gross Weight	Manganese Content	Gross Weight	Manganese Content	Gross Weight	Manganese Content
Angola	.....	.....	8,152	4,291	8,152	4,291
Belgian Congo	.....	.....	5,324	2,585	5,324	2,585
Brazil	5,987	2,535	57,969	26,271	63,956	28,806
Chile	.....	.....	6,332	2,988	6,332	2,988
Cuba	5,899	2,843	40,075	18,118	45,974	20,961
French Morocco	1,646	911	16,934	8,641	18,580	9,552
Greece	.....	.....	440	178	440	178
Gold Coast	30,787	16,973	114,303	55,538	145,090	72,511
India	10,949	5,042	303,810	144,879	314,759	149,921
Mexico	66	29	9,274	4,110	9,340	4,139
Philippines	.....	.....	4,098	1,749	4,098	1,749
Turkey	.....	.....	1,075	473	1,075	473
South Africa	6,909	3,451	242,690	105,742	249,599	109,193
U.S.S.R.	.....	.....	16,107	7,834	16,107	7,834
Totals	62,243	31,784	826,583	383,397	888,826	415,181

Note: General imports comprises ore received at United States ports, part of which went into immediate consumption and the remainder was entered in bond.

Source: Eng. & Min. Jour. Oct. 1950, p. 107.



Table XV-5. MANGANESE ORE (35% OR MORE MANGANESE) IMPORTS FOR CONSUMPTION  
PERCENTAGE OF TOTAL IMPORTS FROM SPECIFIED COUNTRIES, 1934-49.

Year	India	Gold Coast	Cuba	Union of South Africa	Brazil	U.S.S.R.	Mexico	Chile	Philippines	Belgian Congo	Other
1934	6.02	21.58	18.68	-----	16.35	36.57	-----	0.33	----	----	0.47
1935	14.76	24.81	11.46	-----	7.69	39.95	-----	.90	.13	----	.30
1936	15.61	29.70	4.66	.01	13.52	35.64	-----	.47	----	----	.39
1937	7.71	27.92	13.48	.03	8.55	42.10	-----	.04	----	----	.17
1938	5.26	26.24	27.17	-----	6.14	34.34	-----	----	.83	----	.02
1939	14.28	38.73	16.90	.54	6.81	21.57	-----	----	1.11	----	.06
1940	14.78	19.26	10.19	13.87	13.12	24.31	.04	.61	3.39	----	.43
1941	25.28	12.99	15.90	17.89	20.63	1.90	.06	1.07	3.72	----	.56
1942	37.95	11.96	9.87	14.79	20.62	1.13	2.24	.28	----	.18	.98
1943	30.63	14.35	14.01	8.44	24.70	.31	4.00	1.08	----	1.18	1.30
1944	26.36	12.16	35.50	3.14	15.00	-----	6.10	.46	----	1.13	.15
1945	16.05	15.92	22.39	4.72	18.47	11.54	3.94	6.97	----	----	----
1946	21.22	18.47	10.49	16.09	5.67	15.98	2.60	9.48	----	----	----
1947	21.92	16.74	4.40	14.86	12.16	22.27	3.92	3.24	.18	.22	.09
1948	21.37	14.78	2.23	19.24	10.89	26.06	3.65	.70	.68	.18	.22
1949	25.08	19.80	4.27	19.35	14.16	10.61	3.76	1.03	1.00	.45	.49
1950											
1951											
1952											
1953											
1954											
1955											



XVI. EXPORTS AND IMPORTS - WORLD TRADE



## CHAPTER XVI. IMPORTS AND EXPORTS OF WORLD TRADE

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Figures (cont'd.)

Flow of manganese ore to the United States for consumption  
from principal source countries from 1935-39.

Average annual receipts, thousands of long tons.

Figure XVI-5.....XVI- 9





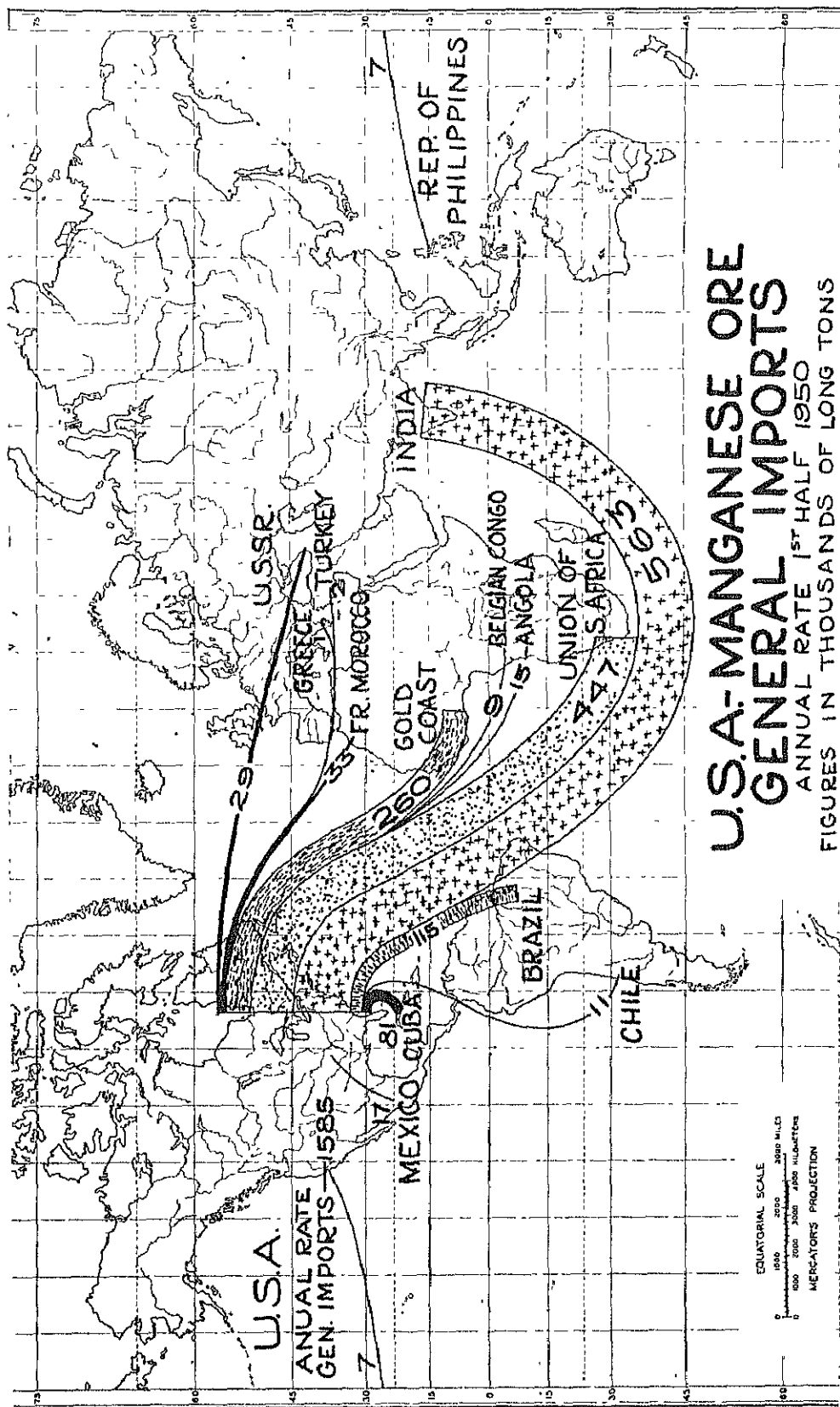


FIGURE XVI-1. Flow of manganese ore to the United States for consumption from principal countries 1950 - General imports, annual rate, thousands of long tons based on receipts for first half year

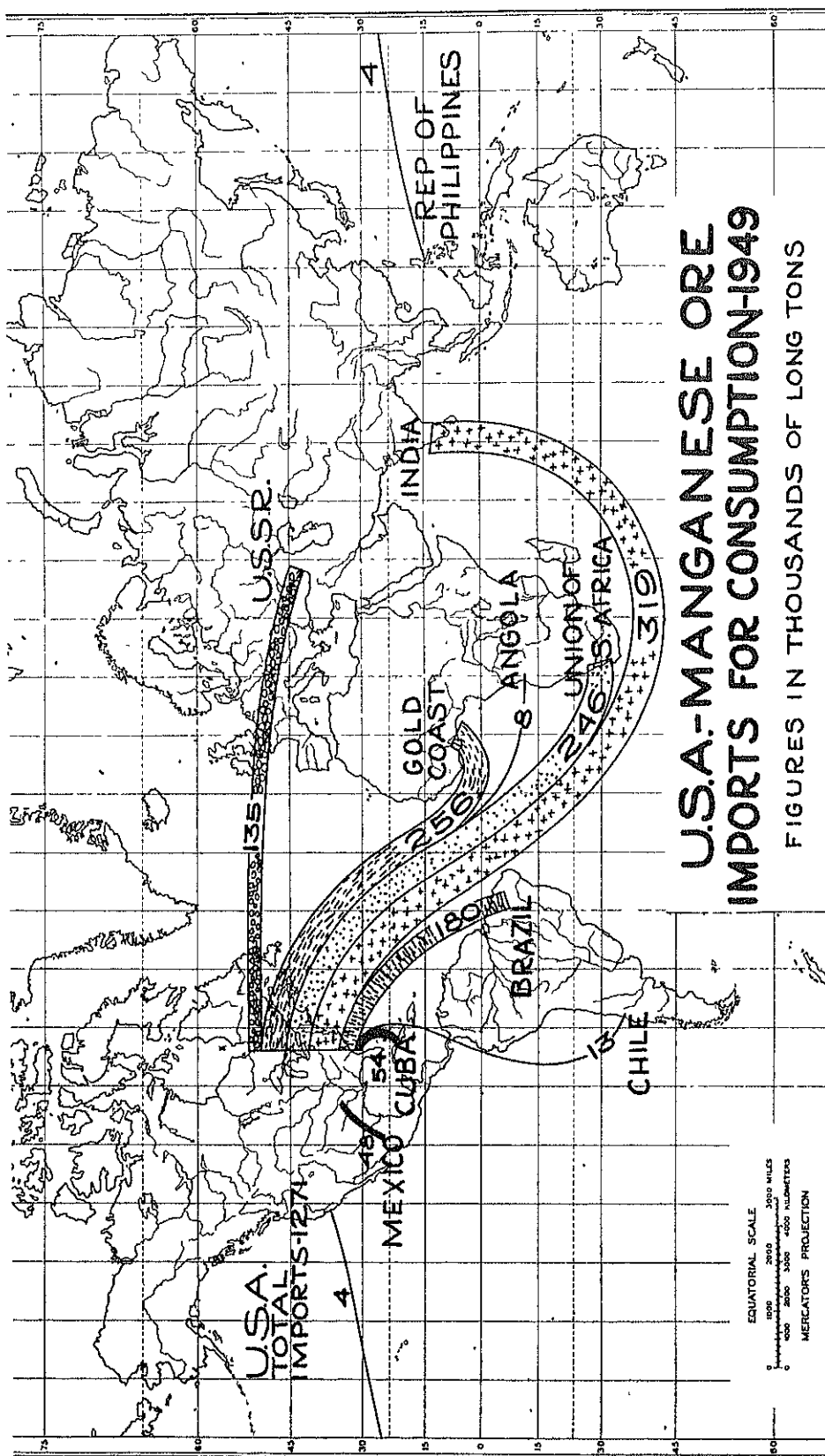


FIGURE XVI-2. Flow of manganese ore to the United States for consumption from principal source countries for 1949, thousands of long tons.

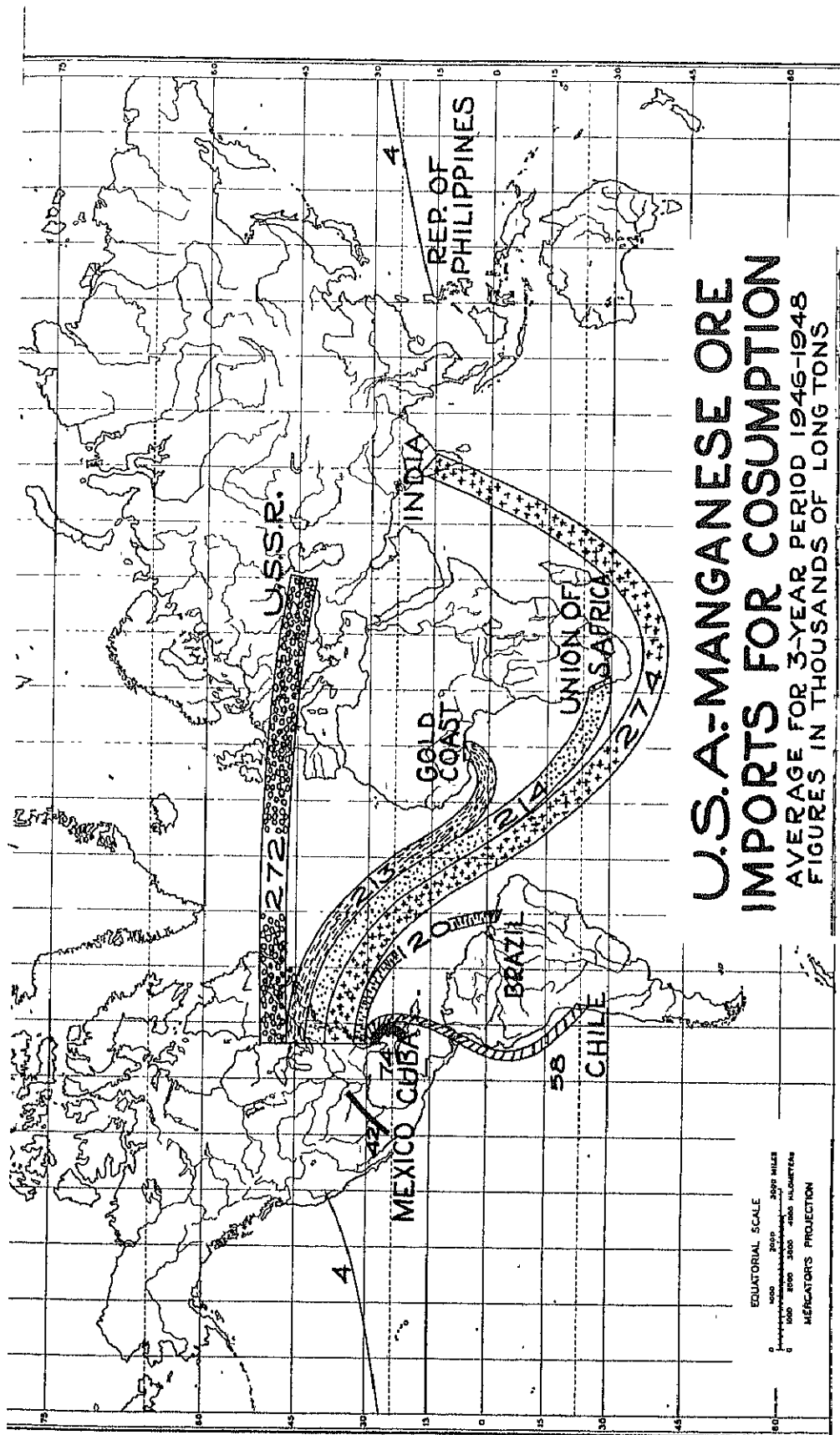


FIGURE XVI-3. Flow of manganese ore to the United States for consumption from principal source countries for 1946-48. Average annual receipts, thousands of long tons.

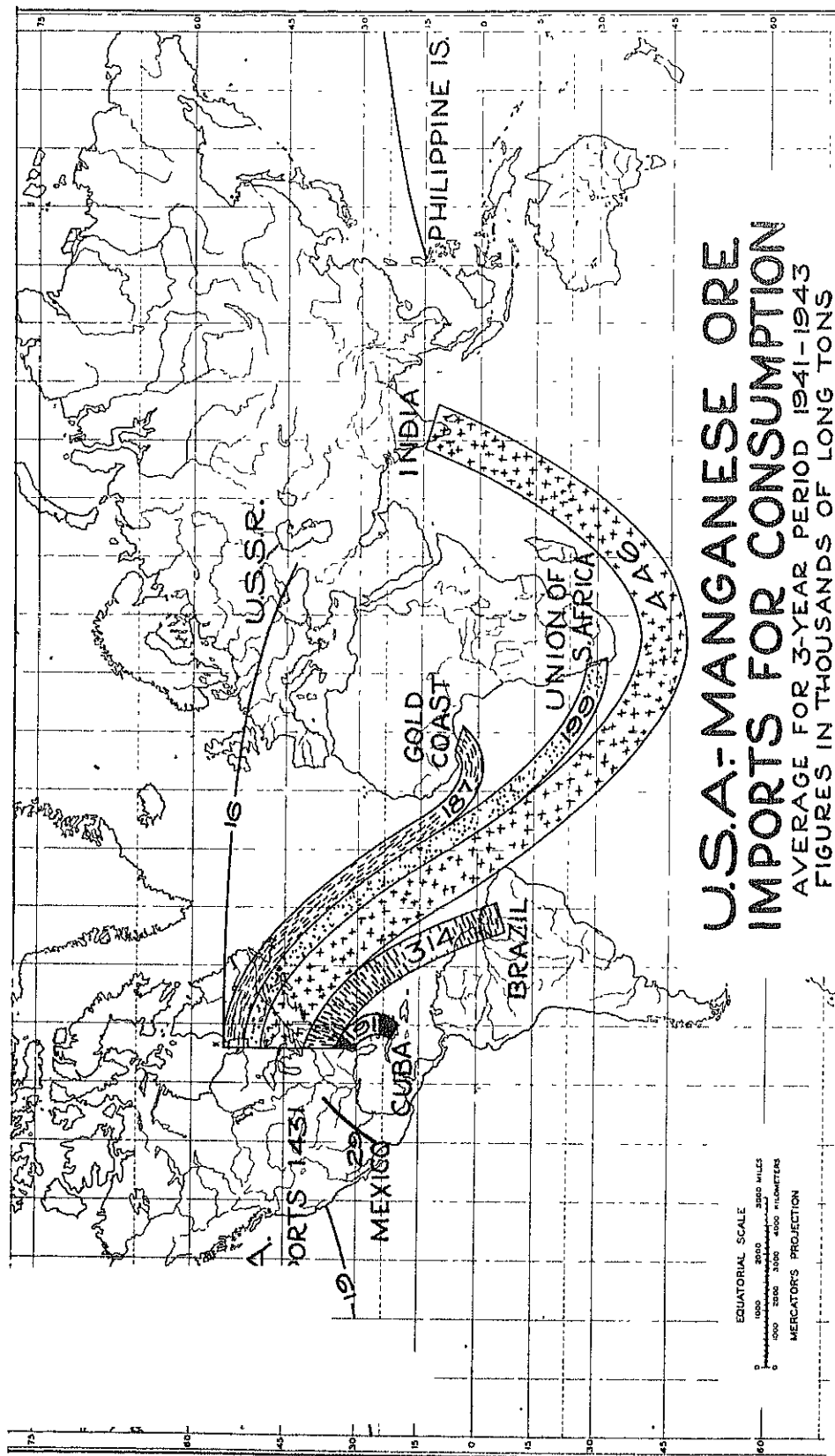


FIGURE XVI-4. Flow of manganese ore to the United States for consumption from principal source countries for 1941-43. Average annual receipts, thousands of long tons.

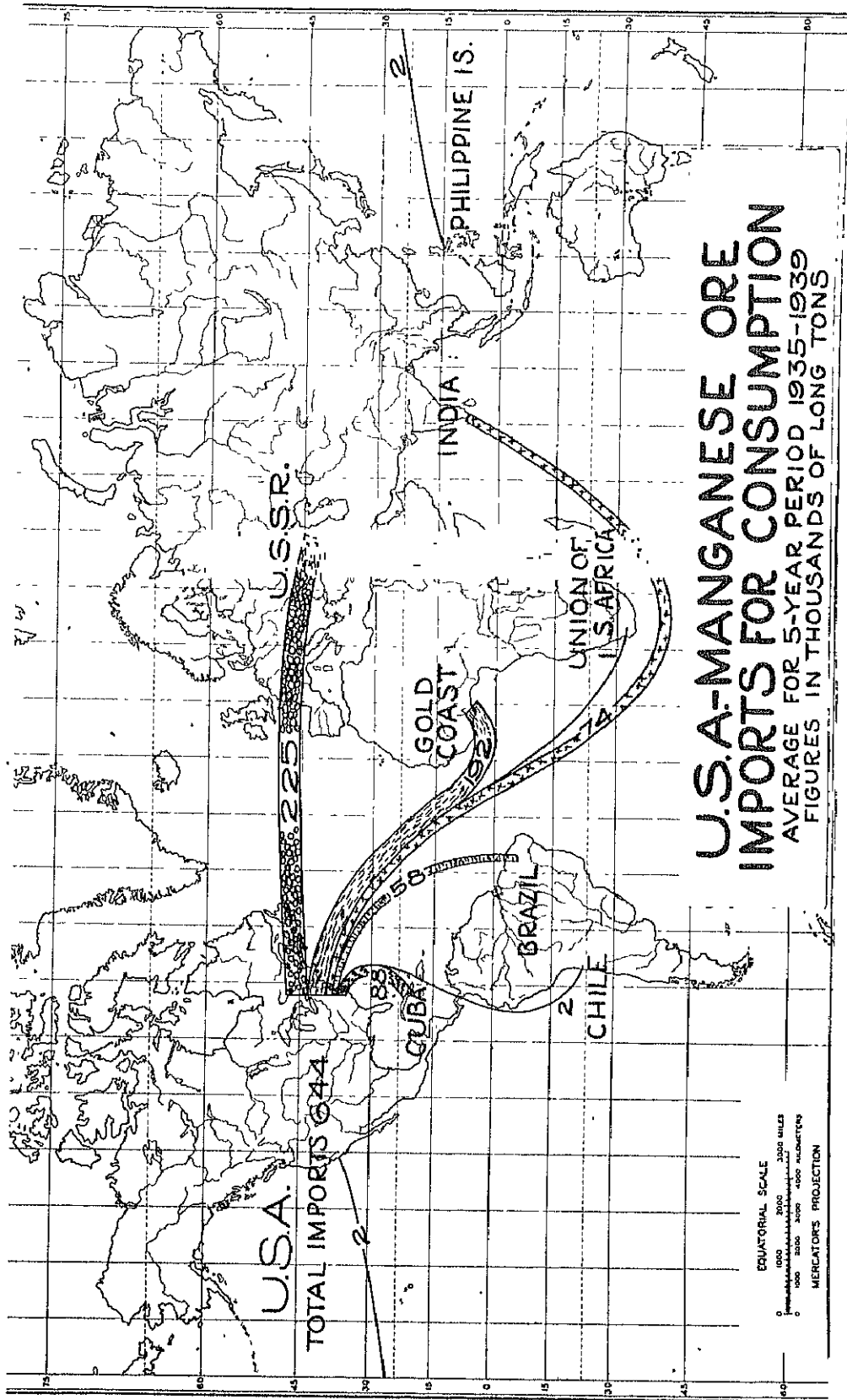


FIGURE XVI-5. Flow of manganese ore to the United States for consumption from principal source countries from 1935-39. Average annual receipts, thousands of long tons.

A. IMPORTS OF MANGANESE ORE

BY

COUNTRIES OF ORIGIN

Belgium

France

Germany

Italy

Netherlands

Norway

United Kingdom

Table XV-1. BELGIUM - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Year	Long Tons								
	Total	France	U.S.S.R	Union of So. Africa	Br. Africa	Br. India	Portuguese India	Brazil	Other
1934	199,839	6,847	84,891	<u>1</u>	8,562	23,507	57,377	5,814	12,841
1935	235,774	872	22,905	<u>1</u>	9,424	29,021	153,762	14,591	5,199
1936	151,849	1,914	32,444	<u>1</u>	<u>2</u>	13,950	72,078	12,487	18,976
1937	335,090	<u>2</u>	81,564	37,079	<u>2</u>	163,447	<u>2</u>	21,724	31,276
1938	193,176	1,436	34,448	15,376	<u>2</u>	99,179	<u>2</u>	17,097 <u>3</u>	25,640
1939	98,240	792	17,480	10,154	<u>2</u>	65,907	<u>2</u>	-	3,907
1940 <u>4</u>									
1941 <u>5</u>	597								
1942 <u>5</u>	478								
1943 <u>5</u>	5,614								
1944 <u>5</u>	429								
1945 <u>5</u>	25,258								
1946 <u>5</u>	58,117								
1947 <u>5</u>	78,737								
1948 <u>6</u>	131,884	<u>2</u>	15,747	39,368	<u>2</u>	50,195	<u>2</u>	<u>2</u>	26,574
1949									
1950									
1951									
1952									

1 Not reported separately; however, the Union of South Africa reported the following exports to Belgium:

1934 7,402 tons

1935 14,477 "

1936 5,919 "

2 Not reported separately; if any, included in "Other".

3 Includes 17,412 tons from Rumania.

4 Not available.

5 Total imports only, reported by Mineral Resources Dept., Imperial Institute, distribution by country is not available.

6 Mn content.

Sources: Bulletin mensuel du commerce de l'Union économique Belgo-Luxembourgeoise avec les pays étrangers, the Mineral Resources Dept., Imperial Institute, and United States Foreign Service Reports.

Table XVI-2. FRANCE - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Long Tons

Page 1 of 2

Year	Total	Germany	U. S. S. R.	Br. India	Other Asia
1934	573, 553	60, 716	203, 929	90, 798	16, 039
1935	366, 029	9, 469	102, 736	126, 543	13, 506
1936	414, 689	107	153, 424	138, 224	17, 355
1937	479, 079	<u>/1</u>	153, 643	193, 329	5, 631
1938	316, 426	<u>/1</u>	108, 306	97, 039	<u>/1</u>
1939	295, 040	<u>/1</u>	130, 781	75, 302	<u>/4</u> 11, 427
1940	197, 023	<u>/1</u>	-	34, 577	5, 785
1941	59, 588	<u>/1</u>	-	-	-
1942	33, 003	<u>/1</u>	-	-	-
1943	97	<u>97</u>	-	-	-
1944	10	10	-	-	-
1945	38, 601	<u>/1</u>	-	-	<u>/1</u>
1946	88, 416	<u>/1</u>	-	-	<u>/1</u>
1947	161, 186	<u>/1</u>	-	-	<u>/1</u>
1948	233, 939	14, 381	-	23, 755	<u>/1</u>
1949	267, 065	<u>/1</u>	-	12, 198	<u>/1</u>
1950				14, 151	<u>/1</u>
1951					
1952					
1953					
1954					
1955					



Table XVI-2. FRANCE - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Long Tons

Page 2 of 2

Year	Union of So. Africa	Algeria	Fr. Morocco	Other Eq. and West Africa	Brazil	Other
1934	15,179	3,972	474	114,019	<u>/1</u>	<u>/2</u> 68,427
1935	15,298	10,589	22,851	36,630	24,296	4,111
1936	17,145	6,382	12,846	18,930	47,500	2,776
1937	26,118	5,501	36,021	31,553	24,137	3,146
1938	17,381	4,431	52,975	4,185	27,660	4,449
1939	18,337	<u>/1</u>	49,523	6,208	-	3,462
1940	36,142	4,380	57,583	55,836	-	2,720
1941	-	<u>/1</u>	58,559	<u>/1</u>	-	1,029
1942	-	<u>/1</u>	32,863	-	-	140
1943	-	-	-	-	-	-
1944	-	-	-	-	-	-
1945	<u>/1</u>	<u>/1</u>	11,868	8,762	-	<u>/5</u> 17,971
1946	<u>/1</u>	<u>/1</u>	59,180	20,443	-	<u>/6</u> 8,793
1947	<u>/1</u>	<u>/1</u>	113,797	<u>/1</u>	-	<u>/6</u> 23,634
1948	14,036	10,344	176,244	5,200	-	1,536
1949	33,518	12,564	196,663	<u>/1</u>	-	10,169

/1 Not reported separately; if any, included in "Other"./2 Includes the following: Greece, 1,600 tons; Sweden, 44,583 tons; Spain, 9,700 tons; Egypt, 11,418 tons./3 Includes Spain, 3,255 tons./4 Includes 6,423 tons from Netherlands Indies./5 Includes 17,963 tons from Cuba./6 Includes the following from other French Union Countries: 1946, 4,055 tons and 1947, 2,210 tons.

Sources: Tableau du commerce exterieur and U. S. Foreign Service Reports.

Table XVI-3. GERMANY - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Page 1 of 3

Long Tons

Year	Total	Sweden	Rumania	United Kingdom	Belgium	France	Czechoslovakia	Hungary	U. S. S. R.
1934	221,196	18	/1	945	58	612	/1	/1	169,222
1935	388,031	35	/1	916	/1	874	/1	/1	224,743
1936	226,008	147	59	840	/1	1,395	/1	4,787	31,576
1937	545,419	304	/1	1,288	/1	2,503	/1	13,501	60,368
1938	419,062	269	-	1,574	-	1,013	-	3,118	59,963
1939	230,920	146	/1	363	15	291	/1	15,366	6,121
1940	117,107	78	4,204	-	2,075	-	10,206	25,514	63,739
1941	235,984	154	11,188	-	3,870	5,089	37,941	22,773	139,811
1942	337,286	157	1,018	-	54	215	13,224	31,583	274,946
1943	376,750	126	1,043	-	/1	187	16,643	28,178	-
1944 /11									
1945 /11									
1946 /11									
1947 /11									
1948	2,759	-	-	10	76	-	-	-	-
1949	60,624	107	-	63	224	238	-	-	873
1950									
1951									
1952									

Table XVI-3. GERMANY - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Long Tons

Page 2 of 3

Year	Greece	Bulgaria	Other European	Turkey	India	Netherlands Indies	Japan	Australia
1934	<u>/1</u>	<u>/1</u>	123 <u>/2</u>	<u>/1</u>	12,527	4,695	3,129	<u>/1</u>
1935	15	<u>/1</u>	18 <u>/3</u>	14,556	72,196	3,958	2,094	<u>/1</u>
1936	143	<u>/1</u>	200 <u>/3</u>	1,884	50,312	5,483	2,305	965
1937	66	<u>/1</u>	17 <u>/3</u>	<u>/1</u>	119,403	5,563	2,269	1,691
1938	161	-	5 <u>/5</u>	-	16,954	8,222	2,135	867
1939	795	<u>/1</u>	44 <u>/7</u>	695	3,438	3,647	1,221	-
1940	39	4,371	1,756 <u>/7</u>	<u>/1</u>	<u>/1</u>	318	77	-
1941	<u>/1</u>	2,807	150 <u>/8</u>	<u>/1</u>	<u>/1</u>	-	141	-
1942	195	4,099	472 <u>/9</u>	<u>/1</u>	<u>/1</u>	-	5	-
1943	<u>/1</u>	226	6,111 <u>/10</u>	<u>/1</u>	<u>/1</u>	-	-	-
1944 <u>/11</u>								
1945 <u>/11</u>								
1946 <u>/11</u>								
1947 <u>/11</u>								
1948	-	-	-	-	-	-	-	-
1949	-	-	666 <u>/13</u>	-	23,230	-	-	-
1950								
1951								
1952								

Table XVI - 3. GERMANY - IMPORTS OF MANGANESE ORE BY COUNTRY OF ORIGIN (Cont'd.)

Long Tons

Page 3 of 3

Year	Egypt	French Morocco	Gold Coast	Union of So. Africa	Belgian Congo	Brazil	Chile	Other
1934	45	517	10,039	18,928	/1	/1	/1	338
1935	697	/1	35,116	30,525	/1	44	/1	2,244
1936	7,870	37	422	106,887	/1	10,001	692	3
1937	96	288	97	286,090	14,026	26,564	4,087	7,198
1938	341	278	313	263,812	1,851	47,015	10,036	1,135
1939	875	95	68	138,025	-	40,185	6,068	13,462
1940	/1	/1	-	/1	-	363	251	4,086
1941	/1	4,907	-	/1	-	/1	/1	7,153
1942	/1	54	-	/1	-	/1	/1	11,264
1943	/1	/1	-	/1	-	/1	/1	236
1944	/1							/14
1945	/1							
1946	/1							
1947	/1							
1948	-	-	331	-	-	-	469	1,873
1949	17,496	352	14	5,420	200	9,463	2,013	12
1950								265
1951								/14
1952								

/1 Not reported separately; if any, included in "Other".

/2 Norway, 33 tons; Netherlands, 28 tons; Spain, 42 ton; Italy, 20 tons.

/3 Spain.

/4 Includes 746 tons from China.

/5 Netherlands.

/6 China, 918 tons; Costa Rica 217 tons.

/7 Yugoslavia.

/8 Serbia.

/9 Spain, 39 tons; Portugal, 433 tons.

/10 Spain, 20 tons; Portugal, 5,071 tons; Italy, 1,020 tons.

/11 Not available.

/12 United States, 726 tons; Indonesia, 984 tons; Pakistan, 163 tons.

/13 Norway, 388 tons; Denmark, 34 tons; Netherlands, 244 tons.

/14 Guatemala 147 tons; Indonesia, 147 tons.

Source: German Monthly Trade Returns.

Long Tons

Page 1 of 3

Year	Total	Belgium-Lux	France	Germany	Netherlands	Rumania
1934	64,253	53	250	191	170	-
1935	120,313	100	615	192	139	-
1936	23,589	-	45	345	130	-
1937	74,194	-	524	107	160	-
1938	57,162	-	388	122	338	-
1939	47,934	-	401	<u>16</u>	-	-
1940	20,541	-	117	<u>16</u>	-	-
1941	21,341	-	37	467	-	8,725
1942	26,925	-	-	8,798	-	17,032
1943 <u>17</u>	24,714	-	-	18,018	-	5,902
1944 <u>18</u>						
1945 <u>18</u>						
1946	203	-	150	-	53	-
1947	40,840	1,272	<u>17</u>	-	214	-
1948	49,789	<u>17</u>	<u>17</u>	-	<u>16</u>	-
1949	46,688	<u>17</u>	<u>17</u>	-	<u>16</u>	-

Table XVI-4. ITALY - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Long Tons

Page 2 of 3

Year	U.S.S.R.	Morocco	Belgian Congo	Br. Eq. and West Africa	Union of So. Africa
1934	38,232	-	-	1,647	3,013
1935	50,465	39	-	20,784	3,216
1936	9,465	48	-	989	-
1937	40,269	26	-	-	-
1938	-	-	-	2,575	-
1939	20,490	-	-	1,994	-
1940	7,452	-	-	5,006	-
1941	409	10,940	-	-	-
1942	-	-	-	-	-
1943 <u>/7</u>	-	-	-	-	-
1944 <u>/8</u>					
1945 <u>/8</u>					
1946	-	-	-	-	-
1947	-	-	978	898	14,796
1948	-	-	4,981	-	7,205
1949	9,875	-	999	-	9,767
1950					
1951					
1952					

Year	Palestine	India	Pakistan	Netherlands Indies	United States	Other
1934	16,961		13	104	44	3,575 /1
1935	6,271		25,752	318	19	12,403 /2
1936	-		12,427	100	10	30 /3
1937	14,865		10,136	70	-	8,037 /4
1938	-		49,789	455	-	3,495 /5
1939	-		24,074	276	-	699
1940	-		2,995	4,802	-	169
1941	-		-	-	-	763
1942	-		-	-	-	1,095
1943 /7	-		-	-	-	794
1944 /8	-		-	-	-	-
1945 /8	-		-	-	-	-
1946	-		-	-	-	-
1947	-		20,967	-	-	-
1948	-		32,205	-	934	781 /9
1949	-	-	23,471	-	-	5,398 /10
						2,576

/1 Includes Algeria, 3,500 tons and Japan 40 tons.

/2 Includes 12,244 tons from Algeria.

/3 Austria.

/4 Includes Algeria, 4,738 tons and Egypt, 3,164 tons.

/5 Turkey, 1,724 tons; French Eq. and West Africa, 1,559 tons; United Kingdom, 212 tons.

/6 Not reported separately; if any, included in "Other".

/7 Jan. through June.

/8 Not available.

/9 Includes 766 tons from the United Kingdom.

/10 Includes Hungary, 2,689 tons and Greece, 1,475 tons.

Source: Statistica del commercio speciale di importazione e di esportazione.

Table XVI-5. NETHERLANDS - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Long Tons

Page 1 of 2

Year	Total	Germany	Belgium-Lux	France	United Kingdom	U.S.S.R.	Union of So. Africa
1934	7,277	152	32	256	-	5,839	<u>/1</u>
1935	1,998	174	33	588	3	108	-
1936	8,413	131	11	227	1	5,842	<u>/1</u>
1937	13,565	198	22	564	-	-	9,337
1938	17,721	41	527	152	175	5,589	9,637
1939	34,116	23	155	366	96	15,282	15,620
1940	433	56	-	-	90	-	-
1941	445	445	-	-	-	-	-
1942	506	506	-	-	-	-	-
1943	116	116	-	-	-	-	-
1944 /5							
1945 /5							
1946	3,040	-	-	<u>/1</u>	383	<u>/1</u>	1,965
1947	18,249	-	-	21	511	<u>/1</u>	3,998
1948	5,052	-	-	98	625	517	1,992
1949	17,724	-	-	137	142	1,442	14,135
1950							
1951							
1952							



Table XVI-5. NETHERLANDS - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Page 2 of 2

Long Tons

Year	Br. West Africa	Egypt	Br. India	Netherlands Indies	United States	Chile	Other
1934	<u>/1</u>	-	50	883	33	<u>/1</u>	32
1935	-	-	-	1,047	45	-	-
1936	<u>/1</u>	-	1,250	792	34	<u>/1</u>	125 <u>/2</u>
1937	49	-	1,250	1,998	47	98	2 <u>/3</u>
1938	<u>/1</u>	-	50	1,531	12	<u>/1</u>	7
1939	400	25	299	1,726	22	-	102 <u>/4</u>
1940	-	-	-	-	26	207	54
1941	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	-
1944 <u>/5</u>							
1945 <u>/5</u>							
1946	197	115	197	<u>/1</u>	-	-	183
1947	200	10,399	299	2,821	-	-	-
1948	788 <u>/6</u>	197	304	<u>/1</u>	-	-	531 <u>/7</u>
1949	601 <u>/8</u>	-	196	<u>/1</u>	-	-	1,071 <u>/9</u>

/1 Not reported separately; if any, included in "Other"./2 Includes 108 tons from French Morocco./3 Sweden./4 French Morocco./5 Not available./6 Gold Coast, 591 tons; Nigeria, 197 tons./7 Includes 511 tons from Indonesia./8 Gold Coast only./9 Includes 984 tons from Indonesia.

Source: Maandastistiek van de in-, uit - en Doorvoer van Nederland and United States Foreign Service Reports.

6. NORWAY - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Long Tons

Page 1 of 2

	Total	United Kingdom	U. S. S. R.	Germany	Belgian Congo
1936	106,841	46,728	21,732	/1	/1
1937	80,052	23,993	12,354	/1	/1
1938	100,961	/1	14,599	/1	/1
1939	128,697	-	20,654	/1	-
1940	122,397	-	11,396	/1	1,486
1941	101,908	-	18,078	/1	/1
1942	54,883	-	3	/1	-
1943	2,497	-	-	2,497	-
1944	16,462	-	-	16,462	-
1945	14,473	-	1,951	12,522	-
1946	32,213	-	7,033	19,607	-
1947	10,415	-	/1	745	-
1948	47,238	7,579	-	-	-
1949	102,571	-	9,881	-	-
1950	131,878	-	4,904	-	-
1951					
1952					

Table XVI-6. NORWAY - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Year	Long Tons					Page 2 of 2	
	French Morocco	Union of So. Africa	Br. West Africa	India	Chile	Other	
1934	/1	/1	33,586	4,150	/1	645	
1935	/1	/1	36,933	3,431	/1	3,341	
1936	/1	/1	70,980	6,693	/1	8,689	
1937	196	-	95,285	6,840	5,722	-	
1938	1,215	-	96,730	353	10,942	275 /2	
1939	990	7,016	72,764	/1	2,534	526	
1940	-	-	53,880	1,000	-	-	
1941	-	-	-	-	-	-	
1942	-	-	-	-	-	-	
1943	-	-	-	-	-	-	
1944	-	-	/1	/1	/1	5,573	
1945	-	-	9,644	/1	/1	26	
1946	-	8,026	20,867	4,953	5,813	-	
1947	-	1,506	88,407	837	1,940	-	
1948	492	5,330	119,629	-	1,523	-	
1949							
1950							
1951							
1952							

/1 Not reported separately; if any, included in "Other".  
 /2 Rhodesia.

Source: Norges Handel and Imperial Institute.

Table XVI-7. UNITED KINGDOM - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Year	Long Tons					Page 1 of 2	
	Total	Br. India	Gold Coast	Union of S. Africa	Sierra Leona	Other British	U.S.S.R.
1934	202,313	156,256	26,380	<u>/1</u>	<u>/1</u>	1,549	5,006
1935	228,036	171,692	30,506	5,846	<u>/1</u>	754	14,180
1936	240,637	199,902	21,428	5,942	<u>/1</u>	500	8,246
1937	283,871	241,726	14,802	8,709	<u>/1</u>	460	14,109
1938	192,715	172,441	13,991	1,015	<u>/1</u>	-	1,510
1939	324,981	234,051	30,491	29,056	<u>/1</u>	10	15,175
1940	247,071	146,636	80,029	2,065	3,524	1	6,765
1941	314,249	95,079	192,674	-	25,641	-	-
1942	421,204	112,994	291,404	1,379	11,868	110	-
1943	444,582	134,469	292,943	-	13,680	-	-
1944	315,251	9,846	305,377	-	-	-	-
1945	314,854	10,916	301,615	-	-	-	-
1946	193,630	9,978	181,143	2,465	-	-	-
1947	268,467	34,014	190,129	44,130	-	-	-
1948	395,777	85,469	238,084	70,034	<u>/1</u>	6	-
1949	471,270	109,706	215,794	90,248	<u>/1</u>	55	-
1950							
1951							
1952							

Table XVI-7. UNITED KINGDOM - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN (Cont'd.)

Page 2 of 2

Long Tons

Year	Belgium	France	Germany	Netherland	Port. India	Algeria	Morocco	Egypt	United States	Brazil	Netherlands E. Indies	Other
1934	988	1,499	-	875	7,204	-	-	<u>/2</u>	804	-	344	1,408
1935	431	1,273	-	1,067	-	-	-	<u>/2</u>	385	-	573	1,329
1936	25	1,722	-	395	51	-	-	<u>/2</u>	204	-	152	2,070
1937	67	1,278	-	399	-	-	-	<u>/2</u>	264	-	546	1,511
1938	-	1,878	-	524	<u>/2</u>	-	16	<u>/2</u>	-	-	-	1,340
1939	-	1,583	-	313	<u>/2</u>	-	4,216	<u>/2</u>	-	7,681	-	2,405
1940	-	-	-	-	<u>/2</u>	-	<u>/2</u>	796	-	<u>/2</u>	2,144	5,111
1941	-	-	-	-	<u>/2</u>	-	<u>/2</u>	758	-	<u>/2</u>	97	-
1942	-	-	-	-	<u>/2</u>	-	<u>/2</u>	3,449	-	<u>/2</u>	-	-
1943	-	-	-	-	<u>/2</u>	-	<u>/2</u>	1,544	-	<u>/2</u>	-	-
1944	-	-	-	-	<u>/2</u>	1,946	<u>/2</u>	28	-	<u>/2</u>	-	-
1945	-	-	2,323	-	<u>/2</u>	-	<u>/2</u>	-	-	<u>/2</u>	-	-
1946	-	44	-	-	<u>/2</u>	-	<u>/2</u>	-	-	<u>/2</u>	-	-
1947	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	150	-	<u>/2</u>	<u>/2</u>	44
1948	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	-	<u>/2</u>	<u>/2</u>	2,184
1949	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	<u>/2</u>	-	<u>/2</u>	<u>/2</u>	55,467
1950												
1951												
1952												

/1 Not reported separately; if any, included in "Other British."/2 Not reported separately; if any, included in "Other".

Source: Customs and Excise Dept. Great Britain, Annual Statement of Trade.

Table XVI-7. UNITED KINGDOM - IMPORTS OF MANGANESE ORE, BY COUNTRY OF ORIGIN

Year	Long Tons					Page 1 of 2	
	Total	Br. India	Gold Coast	Union of S. Africa	Sierra Leona	Other British	U.S.S.R.
1934	202,313	156,256	26,380	<u>/1</u>	<u>/1</u>	1,549	5,006
1935	228,036	171,692	30,506	5,846	<u>/1</u>	754	14,180
1936	240,637	199,902	21,428	5,942	<u>/1</u>	500	8,246
1937	283,871	241,726	14,802	8,709	<u>/1</u>	460	14,109
1938	192,715	172,441	13,991	1,015	<u>/1</u>	-	1,510
1939	324,981	234,051	30,491	29,056	<u>/1</u>	10	15,175
1940	247,071	146,636	80,029	2,065		1	6,765
1941	314,249	95,079	192,674	-	3,524	-	-
1942	421,204	112,994	291,404	1,379	25,641	110	-
1943	444,582	134,469	292,943	-	11,868	-	-
1944	315,251	9,846	305,377	-	13,680	-	-
1945	314,854	10,916	301,615	-	-	-	-
1946	193,630	9,978	181,143	2,465	-	-	-
1947	268,467	34,014	190,129	44,130	-	-	-
1948	395,777	85,469	238,084	70,034	-	-	-
1949	471,270	109,706	215,794	90,248	<u>/1</u>	6	-
1950					<u>/1</u>	55	-
1951							
1952							

Year	United States	Germany	Belgium-Luxembourg	Netherlands	France	United Kingdom	Other	Total
1901	52,084	56	10,198	---	4,970	26,020	5,500	98,828
1902	110,014	38	9,066	3,200	1,450	30,127	3,400	157,295
1903	73,880	9,058	38,695	3,400	6,300	30,593	---	161,926
1904	98,891	9,020	50,042	---	5,607	44,700	---	208,260
1905	88,880	9,013	36,270	2,700	13,738	65,426	8,350	224,377
1906	47,210	4,152	21,904	---	6,000	42,065	---	121,331
1907	50,670	9,543	40,500	35,050	27,650	73,365	---	236,778
1908	19,450	5,500	46,350	11,750	13,970	45,100	23,002	165,122
1909								
1910	59,350	15,300	29,000	27,100	34,550	55,200	33,453	253,953
1911	50,150	14,100	34,840	4,500	7,650	41,801	20,900	173,941
1912	82,530	20,000	10,900	5,800	10,340	25,300	---	154,870
1913	59,400	5,000	11,800	14,700	---	16,800	14,600	122,300
1914	87,630	---	10,600	---	11,400	23,500	50,500	183,630
1915	266,871	---	---	---	---	10,100	11,700	288,671
1916	503,120	---	---	---	---	---	10	503,130
1917	532,855	---	---	---	---	---	---	632,855
1918	392,459	---	---	---	920	---	9	393,388
1919	205,725	---	---	---	---	---	---	205,725
1920	446,229	5	---	100	---	---	7,403	453,737
1921	260,050	2,571	---	5,600	7,117	---	356	275,694
1922	298,396	1,801	219	2,000	31,678	6,400	212	340,706
1923	189,700	106	5,839	---	13,734	26,150	302	235,631
1924	114,207	---	20,301	7,200	---	16,900	621	159,229
1925	243,327	---	7,916	31,950	12,665	6,000	24	301,882
1926	292,187	5	11,522	6,000	9,979	---	132	319,825
1927	161,183	50	54,201	---	26,118	1	270	241,823
1928	226,300	52	61,286	16,613	55,778	1,800	---	361,829
1929	231,752	---	31,123	---	30,443	---	---	293,318
1930	178,485	---	2,366	---	11,101	---	170	192,122
1931	74,050	---	4,060	---	17,440	---	---	95,550
1932	8,900	---	11,985	---	---	---	---	20,885
1933	---	---	10,262	---	14,631	---	---	24,893
1934	2,300	---	---	---	---	---	---	2,300
1935	26,695	---	14,602	211	19,138	1	22	60,669
1936	74,463	---	14,332	19,626	48,063	---	9,987	166,471
1937	148,704	1,476	28,382	16,155	41,009	---	11,389	247,115
1938	44,908	17,831	19,332	36,643	11,728	---	6,401	136,843
1939	134,963	37,306	3,658	4,572	---	---	8,504	189,003
1940	215,601	---	7,112	---	---	---	---	222,713
1941	423,682	---	---	---	---	---	13,720	437,402
1942	306,241	---	---	---	---	---	---	306,241
1943	275,552	---	---	---	---	---	---	275,552
1944	146,782	---	---	---	---	---	200	146,982
1945	244,549	---	---	---	---	---	100	244,649
1946	149,149	---	---	---	---	---	---	149,149
1947	142,092	---	---	---	---	---	---	142,092
1948	140,237	---	---	1,016	---	---	---	141,253
1949	139,345	---	3,048	7,503	---	---	---	149,896
Total	8,121,188	161,978	661,711	263,389	495,167	587,349	231,237	10,522,034

Source: Departamento nacional de producao mineral.

Mineral Trade Notes, Bureau of Mines, vol. 31, No. 4, October 1950, p. 20.

B. EXPORTS OF MANGANESE ORE

By

COUNTRIES OF DESTINATION

Belgium

Brazil

Germany

India

Netherlands

Union of South Africa

Gold Coast



Table XVI-8. BELGIUM - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Long Tons

Year	Total	France	Germany	Norway	Poland and Danzig	Other
1934	10,100	8,995	983	<u>/1</u>	<u>/1</u>	122
1935	6,836	1,776	2,865	1,998	<u>/1</u>	197
1936	12,123	5,869	3,807	2,409	<u>/1</u>	38
1937	2,775	1,346	398	<u>/1</u>	-	1,031
1938	13,704	8,271	1,268	<u>/1</u>	989	3,176
1939	10,752	3,681	1,789	<u>/1</u>	115	5,167
1940 <u>/2</u>						
1941 <u>/3</u>	1					
1942	-					
1943	-					
1944	-					
1945	-					
1946 <u>/3</u>						
1947 <u>/2</u>						
1948 <u>/2</u>						
1949 <u>/2</u>						

/1 Not reported separately; if any, included in "Other."/2 Not available./3 Destination is not reported.

Sources: Bulletin mensuel du commerce de l' Union economique  
 Belgo-Luxembourgeois avec pays etrangers and the Mineral  
 Resources Dept., Imperial Institute.

Table XVI-9. BRAZIL - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Long Tons

Year	Total	United States	Germany	Belgium- Lux.	Netherlands	France	Other
1934	2,264	2,264	-	-	-	-	-
1935	59,711	26,273	-	14,371	208	18,836	23
1936	163,842	73,287	-	14,106	19,316	47,304	9,829
1937	243,212	146,356	1,453	27,934	15,900	40,361	11,208
1938	134,682	44,199	17,549	19,027	36,064	11,543	6,300
1939	186,019	132,832	36,717	3,600	4,500	-	8,370
1940	219,196	212,196	-	7,000	-	-	-
1941	430,494	416,992	-	-	-	-	13,502
1942	301,405	301,405	-	-	-	-	-
1943	271,200	271,200	-	-	-	-	-
1944	144,662	144,464	-	-	-	-	198
1945	240,785	240,687	-	-	-	-	98
1946	146,793	146,793	-	-	-	-	-
1947	139,848	139,848	-	-	-	-	-
1948	139,024	139,024	-	-	1,000	-	-
1949	147,529	137,145	-	3,000	7,384	-	-

Source: Departamento nacional de producao mineral (Foreign Service Report, Rio de Janeiro, No. 409, 9/14/50).

Table XVI-10. EXPORTS OF MANGANESE ORE FROM BRAZIL, 1901-49, metric tons

Year	United States	Germany	Belgium-Luxembourg	Netherlands	France	United Kingdom	Other	Total
1901	52,084	56	10,198	---	4,970	26,020	5,500	98,828
1902	110,014	38	9,066	3,200	1,450	30,127	3,400	157,295
1903	73,880	9,058	38,695	3,400	6,300	30,593	---	161,926
1904	98,891	9,020	50,042	---	5,607	44,700	---	208,260
1905	88,880	9,013	36,270	2,700	13,738	65,426	8,350	224,377
1906	47,210	4,152	21,904	---	6,000	42,065	---	121,331
1907	50,670	9,543	40,500	35,050	27,650	73,365	---	236,778
1908	19,450	5,500	46,350	11,750	13,970	45,100	23,002	165,122
1909								
1910	59,350	15,300	29,000	27,100	34,550	55,200	33,453	253,953
1911	50,150	14,100	34,840	4,500	7,650	41,801	20,900	173,941
1912	82,530	20,000	10,900	5,800	10,340	25,300	---	154,870
1913	59,400	5,000	11,800	14,700	---	16,800	14,600	122,300
1914	87,630	---	10,600	---	11,400	23,500	50,500	183,630
1915	266,871	---	---	---	---	10,100	11,700	288,671
1916	503,120	---	---	---	---	---	10	503,130
1917	532,855	---	---	---	---	---	---	632,855
1918	392,459	---	---	---	920	---	9	393,388
1919	205,725	---	---	---	---	---	---	205,725
1920	446,229	5	---	100	---	---	7,403	453,737
1921	260,050	2,571	---	5,600	7,117	---	356	275,694
1922	298,396	1,801	219	2,000	31,678	6,400	212	340,706
1923	189,700	106	5,839	---	13,734	26,150	302	235,831
1924	114,207	---	20,301	7,200	---	16,900	621	159,229
1925	243,327	---	7,916	31,950	12,665	6,000	24	301,882
1926	292,187	5	11,522	6,000	9,979	---	132	319,825
1927	161,183	50	54,201	---	26,118	1	270	241,823
1928	226,300	52	61,286	16,613	55,778	1,800	---	361,829
1929	231,752	---	31,123	---	30,443	---	---	293,318
1930	178,485	---	2,366	---	11,101	---	170	192,122
1931	74,050	---	4,060	---	17,440	---	---	95,550
1932	8,900	---	11,985	---	---	---	---	20,885
1933	---	---	10,262	---	14,631	---	---	24,893
1934	2,300	---	---	---	---	---	---	2,300
1935	26,695	---	14,602	211	19,138	1	22	60,669
1936	74,463	---	14,332	19,626	48,063	---	9,987	166,471
1937	148,704	1,476	28,382	16,155	41,009	---	11,389	247,115
1938	44,908	17,831	19,332	36,643	11,728	---	6,401	136,843
1939	134,963	37,306	3,658	4,572	---	---	8,504	189,003
1940	215,601	---	7,112	---	---	---	---	222,713
1941	423,682	---	---	---	---	---	13,720	437,402
1942	306,241	---	---	---	---	---	---	306,241
1943	275,552	---	---	---	---	---	---	275,552
1944	146,782	---	---	---	---	---	200	146,982
1945	244,549	---	---	---	---	---	100	244,649
1946	149,149	---	---	---	---	---	---	149,149
1947	142,092	---	---	---	---	---	---	142,092
1948	140,237	---	---	1,016	---	---	---	141,253
1949	139,345	---	3,048	7,503	---	---	---	149,896
Total	8,121,188	161,978	661,711	263,389	495,167	587,349	231,237	10,522,034

Source: Departamento nacional de producao mineral.

Mineral Trade Notes, Bureau of Mines, vol. 31, No. 4, October 1950, p. 20.

- EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Long Tons

Year	Total	United States	Germany	Belgium-Lux.	Netherlands	France	Other
1934	2,264	2,264	-	-	-	-	-
1935	59,711	26,273	-	14,371	208	18,836	23
1936	163,842	73,287	-	14,106	19,316	47,304	9,829
1937	243,212	146,356	1,453	27,934	15,900	40,361	11,208
1938	134,682	44,199	17,549	19,027	36,064	11,543	6,300
1939	186,019	132,832	36,717	3,600	4,500	-	8,370
1940	219,196	212,196	-	7,000	-	-	-
1941	430,494	416,992	-	-	-	-	13,502
1942	301,405	301,405	-	-	-	-	-
1943	271,200	271,200	-	-	-	-	-
1944	144,662	144,464	-	-	-	-	198
1945	240,785	240,687	-	-	-	-	98
1946	146,793	146,793	-	-	-	-	-
1947	139,848	139,848	-	-	-	-	-
1948	139,024	139,024	-	-	-	-	-
1949	147,529	137,145	-	3,000	1,000	-	-
					7,384	-	-

Source: Departamento nacional de producao mineral (Foreign Service Report, Rio de Janeiro, No. 409, 9/14/50).

Table XVI-13. INDIA - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION /1

Long Tons

Year	Total	United States	United Kingdom	Belgium	France	Germany	Italy	Japan	Other
1934	392,296	30,083	161,430	19,397	87,622	/2	/2	85,102	8,662
1935	702,287	77,760	182,816	72,897	131,977	16,615	15,775	176,373	28,074
1936	633,823	109,102	219,041	62,015	93,346	12,617	1,000	108,374	28,328
1937	981,189	143,102	272,265	137,437	185,203	18,035	19,114	178,547	27,486
1938	518,342	89,037	145,086	8,962	80,950	3,609	48,150	113,212	29,336
1939	654,390	125,226	244,038	20,791	64,199	345	24,189	159,171	16,431
1940	664,853	254,266	100,220	16,014	18,291	/2	/2	210,153	65,909
1941	558,455	366,931	140,515	/2	/2	/2	/2	51,000	9
1942	599,254	460,988	132,251	/2	/2	/2	/2	/2	6,015
1943	712,424	594,007	103,514	/2	/2	/2	/2	/2	14,903
1944	151,621	145,379	6,237	/2	/2	/2	/2	/2	5
1945	171,276	153,646	17,629	/2	/2	/2	/2	/2	1
1946	434,600	377,093	9,412	/2	/2	/2	/2	/2	48,095
1947	491,044	330,888	54,786	23,083	18,700	2,921	39,344	/2	21,322
1948	354,639	197,624	75,414	13,692	10,736	-	30,211	23,649	3,313
1949	543,111	348,886	94,682	12,681	10,850	18,102	14,300	20,867	22,743
1950									
1951									
1952									

/1 Data exclude exports of manganese ore from Portuguese India.

/2 Not reported separately; if any, included in "Other."

Source: 1934-37 Records of Geological Survey of India; 1937-46, accounts relating to Seaborne Trade of India; 1947-48 - reports from the Foreign Service of the United States.

XVI-33

ANY - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Long Tons

Page 1 of 2

	Sweden	Denmark	Netherlands	Belgium	Hungary	Czechoslovakia
1930	84	/1	282	/1	/1	254
1939	110	/1	63	88	/1	338
1940	-	276	-	80	98	270
1941	/1	/1	/1	127	27	154
1942	57	54	/1	/1	/1	121
1943	153	/1	/1	/1	/1	/1
1944	83	152	39	172	103	/1
1945	143	299	433	490	46	/1
1946	360	340	383	420	67	/1
1947	204	/1	/1	2,154	/1	/1
1948	-					
1949	138					
1950						
1951						
1952						

Table XVI-11. GERMANY - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION (Cont'd.)

Page 2 of 2

Long Tons

Year	Finland	Italy	Yugoslavia	Rumania	Switzerland	Other
1934	<u>/1</u>	168	<u>/1</u>	94	<u>/1</u>	1,167 <u>/2</u>
1935	<u>/1</u>	186	<u>/1</u>	100	<u>/1</u>	706 <u>/3</u>
1936	-	111	31	111	-	339 <u>/4</u>
1937	<u>/1</u>	34	59	60	<u>/1</u>	327
1938	<u>/1</u>	<u>/1</u>	114	107	<u>/1</u>	305 <u>/5</u>
1939	<u>/1</u>	40	90	31	<u>/1</u>	146
1940	<u>/1</u>	72	167	216	68	146 <u>/6</u>
1941	137	139	<u>/1</u>	199	93	335 <u>/7</u>
1942	304	487	<u>/1</u>	297	144	979
1943	138	184	<u>/1</u>	<u>/1</u>	50	5,815
1944 <u>/8</u>						
1945 <u>/8</u>						
1946 <u>/8</u>						
1947 <u>/8</u>						
1948						
1949 <u>/9</u>						

/1 Not reported separately; if any, included in "Other."/2 Includes the following: United Kingdom, 163 tons; Australia, 115 tons; Austria, 113 tons; Poland 157 tons./3 Includes the following: United Kingdom, 136 tons; Austria, 106 tons; Poland 154 tons./4 Includes the following: United Kingdom 61 tons; Austria 56 tons; Poland 42 tons./5 Includes 64 tons to Argentina./6 Includes 55 tons to Norway./7 Includes 79 tons to Norway./8 Not available./9 Distribution by country is not available.

Source: German Monthly Trade Returns.

Table XVI-12. GOLD COAST - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Long Tons

Year	Total	United States	United Kingdom	Norway	Canada	France	Belgium	Germany	Netherlands	Italy	Other
1934	339,985	80,973	29,394	59,616	21,934	103,509	26,950	298	3,265	4,656	9,390 /1
1935	398,718	143,867	25,681	64,617	29,882	39,374	38,704	24,033	5,244	23,059	4,257 /2
1936	411,024	263,843	20,592	70,707	46,311	9,168	-	403	-	-	-
1937	527,036	316,102	14,470	94,537	83,617	4,216	-	6,138	-	-	7,956 /3
1938	324,207	186,298	13,240	94,129	23,514	2,788	-	328	-	3,910	-
1939	336,312	179,707	31,184	87,092	7,018	20,764	1,390	66	373	1,880	6,838 /4
1940	477,322	234,522	103,789	30,928	53,907	54,167	-	-	-	-	-
1941	428,736	149,120	279,616	-	-	-	-	-	-	-	-
1942	483,573	209,750	273,823	-	-	-	-	-	-	-	-
1943	423,393	108,551	314,842	-	-	-	-	-	-	-	-
1944	504,458	209,514	286,421	-	8,523	-	-	-	-	-	-
1945	692,750	363,970	283,979	10,000	7,268	11,365	15,237	-	-	931	-
1946	765,300	377,745	273,523	47,923	42,715	19,252	4,142	-	-	-	-
1947	588,919	288,996	190,823	72,417	32,003	4,680	-	-	-	-	-
1948	629,974	276,947	211,866	114,195	22,125	4,841	-	-	-	-	-
1949	663,392	359,953	196,846	92,744	5,562	8,287	-	-	-	-	-

/1 Spain and Poland, 4,695 tons each.

/2 Spain.

/3 Czechoslovakia.

/4 Poland.

Source: Mineral Industry of the British Empire and Foreign Countries, Statistics Survey, Imperial Institute, London; Gold Coast Trade Reports; and Foreign Service of the United States.



Table XVI-13. INDIA - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION /1

Long Tons

Year	Total	United States	United Kingdom	Belgium	France	Germany	Italy	Japan	Other
1934	392,296	30,083	161,430	19,397	87,622	/2	/2	85,102	8,662
1935	702,287	77,760	182,816	72,897	131,977	16,615	15,775	176,373	28,074
1936	633,823	109,102	219,041	62,015	93,346	12,617	1,000	108,374	28,328
1937	981,189	143,102	272,265	137,437	185,203	18,035	19,114	178,547	27,486
1938	518,342	89,037	145,086	8,962	80,950	3,609	48,150	113,212	29,336
1939	654,390	125,226	244,038	20,791	64,199	345	24,189	159,171	16,431
1940	664,853	254,266	100,220	16,014	18,291	/2	/2	210,153	65,909
1941	558,455	366,931	140,515	/2	/2	/2	/2	51,000	9
1942	599,254	460,988	132,251	/2	/2	/2	/2	/2	6,015
1943	712,424	594,007	103,514	/2	/2	/2	/2	/2	14,903
1944	151,621	145,379	6,237	/2	/2	/2	/2	/2	5
1945	171,276	153,646	17,629	/2	/2	/2	/2	/2	1
1946	434,600	377,093	9,412	/2	/2	/2	/2	/2	48,095
1947	491,044	330,888	54,786	23,083	18,700	2,921	39,344	/2	21,322
1948	354,639	197,624	75,414	13,692	10,736	-	30,211	23,649	3,313
1949	543,111	348,886	94,682	12,681	10,850	18,102	14,300	20,867	22,743
1950									
1951									
1952									

/1 Data exclude exports of manganese ore from Portuguese India.

/2 Not reported separately; if any, included in "Other."

Source: 1934-37 Records of Geological Survey of India; 1937-46, accounts relating to Seaborne Trade of India; 1947-48 - reports from the Foreign Service of the United States.

India

Preliminary figures on exports of manganese ore from India in 1950 have been reported as follows:

	<u>Long Tons</u>
United States	585,971
United Kingdom	117,793
Japan	33,488
Germany	24,440 <u>/1</u>
Canada	9,300
Belgium	8,800
Norway	3,800
Italy	3,000
Bizone	2,937
Yugoslavia	1,900
France	2,150
Sweden	1,655
Burma	<u>27</u>
Total	795,261

/1 Does not include 230 tons of manganese dioxide ore from Visakhapatnam.

Source: Bureau of Mines Mineral Trade Notes, vol. 32, No. 2, February 1951, p. 15.

Table XVI-24. UNITED STATES - IMPORTS FOR CONSUMPTION OF FERROMANGANESE, BY COUNTRY OF ORIGIN

(Mn Content)

Long Tons

Year	Total	Canada	Norway	United Kingdom	Netherlands	France	Czechoslovakia	Poland and Danzig	Japan	India	Other
1934	18,702	2,226	12,387	2,041	258	440	-	734	-	-	616
1935	21,829	40	14,365	2,347	1,095	2,091	-	157	-	-	1,734
1936	30,594	1	20,655	478	4,347	2,151	557	1,997	257	-	151
1937	23,888	3,385	17,468	128	282	760	944	156	722	-	43
1938	21,118	-	10,547	-	5,843	1,137	3,043	-	308	-	240
1939	33,414	11	19,563	-	7,974	846	2,050	1,598	-	-	1,383
1940	8,573	-	8,538	-	-	-	-	-	35	-	0
1941	5,086	1,073	12	4,001	-	-	-	-	-	-	0
1942	10,388	4,500	-	5,888	-	-	-	-	-	-	0
1943	884	-	-	-	-	-	-	-	-	884	0
1944	2,954	1,993	-	-	-	-	-	-	-	961	0
1945	24,727	24,727	-	-	-	-	-	-	-	-	0
1946	23,132	16,351	6,781	-	-	-	-	-	-	-	0
1947	58,197	48,936	9,261	-	-	-	-	-	-	-	0
1948	70,023	51,319	18,704	-	-	-	-	-	-	-	0
1949	46,578	23,021	23,500	-	-	-	-	-	11	-	46
1950											
1951											
1952											

/1 Less than 1 ton.

Source: Minerals Yearbook. Bureau of Mines, U. S. Department of Interior.

Table XVI-14. NETHERLANDS - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION

Year	Long Tons					Page 1 of 2	
	Total	Germany	Belgium-Lux.	Italy	United Kingdom	Czechoslovakia	
1934	904	153	71	132	234	-	-
1935	853	82	111	239	72	20	20
1936	708	49	107	<u>/1</u>	87	35	35
1937	1,609	280	120	188	54	228	228
1938	1,335	107	85	293	58	183	183
1939	1,898	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>
1940	247	5	17	-	31	-	-
1941	-	-	-	-	-	-	-
1942	1,913	1,895	18	-	-	-	-
1943	-	-	-	-	-	-	-
1944 <u>/2</u>							
1945 <u>/2</u>							
1946	233	<u>/1</u>	-	54	-	124	124
1947	839	<u>/1</u>	-	234	-	18	18
1948	2,134	1,146	-	93	-	<u>/1</u>	<u>/1</u>
1949	2,022	840	-	135	-	191	191
1950							
1951							
1952							

Table XVI-14. NETHERLANDS - EXPORTS OF MANGANESE ORE, BY COUNTRY OF DESTINATION (Cont'd.)

Long Tons

Page 2 of 2

Year	Denmark	Austria	Sweden	Poland and Danzig	Finland	Other
1934	32	-	58	33	18	173
1935	62	-	89	56	11	111
1936	78	69	124	61	20	78
1937	43	74	187	177	20	238
1938	57	12	77	231	33	199
1939	<u>11</u>	<u>11</u>	<u>11</u>	<u>11</u>	<u>11</u>	1,898
1940	-	-	84	-	31	79
1941	-	-	-	-	-	-
1942	-	-	-	-	-	-
1943	-	-	-	-	-	-
1944 <sup>/2</sup>						
1945 <sup>/2</sup>	<u>11</u>	<u>11</u>	<u>11</u>	-	<u>11</u>	55
1946	259	<u>11</u>	88	-	89	151
1947	27	130	192	-	142	404
1948	<u>11</u>	116	134	49	100	457 <sup>/3</sup>
1949						
1950						
1951						
1952						

<sup>/1</sup> Not reported separately; if any, included in "Other."<sup>/2</sup> Not available.<sup>/3</sup> Includes Yugoslavia, 178 tons; Rumania, 97 tons.

Source: Maandstatistiek van de in -, uit - en doorvoer van Nederland and United States Foreign Service Reports.

Table XVI-15. UNION OF SOUTH AFRICA - EXPORTS OF MANGANESE ORE,  
BY COUNTRY OF DESTINATION

Long Tons

Page 1 of 2

Year	Total	United States	United Kingdom	Germany	Belgium	France	Netherlands
1934	65,178	-	2,484	6,005	7,402	16,014	18,969
1935	80,222	-	5,103	7,828	14,477	12,436	27,790
1936	204,558	1,125	6,024	82,958	5,919	34,381	51,674
1937	474,633	16,714	14,398	303,015	54,628	41,831	19,072
1938	314,013	41,471	9,228	208,950	-	15,087	15,150
1939	327,448	70,754	22,850	171,576	2,442	25,069	8,288
1940	286,742	244,390	-	-	1,500	31,925	1,500
1941	303,799	303,799	-	-	-	-	-
1942	179,751	179,751	-	-	-	-	-
1943	76,160	76,159	1	-	-	-	-
1944	9,948	9,873	-	-	-	-	-
1945	132,706	127,514	-	-	-	-	212
1946	316,350	241,550	7,965	-	21,838	-	3,781
1947	332,578	231,971	59,462	-	15,325	12,020	2,000
1948	318,254	175,970	60,016	-	37,483	21,810	3,775
1949	681,841	373,244	100,000	-	63,243	38,200	38,669
1950							
1951							
1952							

Table XVI-15. UNION OF SOUTH AFRICA - EXPORTS OF MANGANESE ORE,  
BY COUNTRY OF DESTINATION (Cont'd.)

Page 2 of 2

Long Tons

Year	Norway	Sweden	Czechoslovakia	Italy	Canada	Japan	Other
1934	-	5,004	-	2,621	5,014	1,665	-
1935	-	5,992	500	180	5,217	699	-
1936	4,900	5,940	5,629	-	5,000	11	997 /1
1937	-	-	15,066	-	9,909	-	-
1938	-	273	23,854	-	-	-	-
1939	7,016	3,714	-	-	6,427	-	9,312 /2
1940	-	3,979	-	-	-	-	3,448 /3
1941	-	-	-	-	-	-	-
1942	-	-	-	-	-	-	-
1943	-	-	-	-	-	-	75 /4
1944	-	-	-	-	-	-	-
1945	-	4,980	-	-	-	-	-
1946	-	-	25,219	-	-	-	-
1947	1,500	1,000	-	11,992	-	-	4,005 /2
1948	6,200	3,000	-	9,000	-	-	300 /5
1949	30,762	10,500	-	10,000	-	-	-
				9,000			18,223 /6

/1 Poland

/2 Yugoslavia

/3 Spain.

/4 Argentina

/5 Finland

/6 Australia - 8,400 tons; Luxembourg - 9,823 tons.

Sources: Annual statement of the Trade and Shipping of the Union of South Africa; Quarterly Information Circular, Dept. of Mines, Union of So. Africa; Imperial Institute, Mineral Resources Dept. "Manganese" by A. W. Groves, 1938.

C. EXPORTS AND IMPORTS OF FERRO-ALLOYS

By

COUNTRIES

France

Italy

Norway

United Kingdom

United States



Table XVI-16. FRANCE - IMPORTS OF FERROMANGANESE

Long Tons

Year	Total	United Kingdom	Belgium-Lux.	Germany	Norway	United States	Other
1934	28	-	/1	21	/1	-	7 /2
1935	81	-	/3	-	68	-	13 /4
1936	395	-	/1	/1	382	-	13
1937	174	-	39	-	135	-	-
1938	682	-	-	-	622	-	60 /5
1939	1,313	-	/1	/1	1,293	-	20
1940	24	-	-	-	2	/3	22 /6
1941	-	-	-	-	-	-	-
1942	39	-	39	-	-	-	-
1943	356	-	59	-	-	-	-
1944	2,147	-	739	297	-	-	-
1945	1,987	1,876	-	1,408	-	-	-
1946	12,330	12,328	-	-	-	111	-
1947	11,905 /7	-	-	-	-	2	-
1948	-	-	-	--	-	-	-
1949	-	-	-	-	-	-	-

/1 Not reported separately; if any, included in "Other."

/2 Italy, 5 tons; Other, 2 tons.

/3 Less than 0.5 tons.

/4 Sweden

/5 Low countries.

/6 Switzerland.

/7 French overseas territories, none; foreign countries, 11,905 tons. No breakdown available.

Sources: Tableau general du commerce exterieur and U. S. Foreign Service Reports.

Table XVI-17. FRANCE - EXPORTS OF FERROMANGANESE

## Long Tons

Year	Total	United Kingdom	Belgium Lux.	Sweden	Switzerland	Italy	Germany	United States	Other
1934	8,433	578	4,789	1,004	<u>/1</u>	301	<u>/1</u>	390	1,371 <u>/2</u>
1935	9,423	357	2,927	2,461	<u>/1</u>	<u>/1</u>	<u>/1</u>	3,017	661
1936	7,240	278	568	1,025	256	<u>/1</u>	<u>/1</u>	3,924	1,189 <u>/3</u>
1937	8,876	511	6,645	261	314	<u>/1</u>	<u>/1</u>	781	364
1938	13,645	516	7,419	3,180	589	<u>/1</u>	<u>/1</u>	1,270	671
1939	8,158	1,339	5,085	-	587	<u>/1</u>	-	1,005	142
1940	1,926	1,520	90	-	102	80	-	-	134
1941	2	-	-	-	-	-	-	-	2 <u>/4</u>
1942	141	-	10	-	32	-	18	-	81 <u>/5</u>
1943	630	-	615	-	<u>/1</u>	-	<u>/1</u>	-	15
1944	1,235	-	-	-	-	-	1,235	-	-
1945	17	-	10	-	7	-	-	-	-
1946	334	153	90	<u>/1</u>	20	<u>/1</u>	<u>/1</u>	-	71 <u>/6</u>
1947	951 <u>/7</u>	-	-	-	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	-	-

/1 Not reported separately; if any, included in "Other."/2 Includes the following: Rumania, 848 tons; French Union, 8 tons./3 Includes Spain, 939 tons./4 Algeria 1 ton; Tunisia, 1 ton./5 Algeria, 32 tons; French Morocco, 40 tons; Other, 9 tons./6 Includes Algeria, 37 tons./7 French overseas territories, 21 tons; foreign countries, 930 tons./8

Sources: Tableau general du commerce exterieur and U. S. Foreign Service Reports.

Table XVI-18. ITALY - IMPORTS OF FERROMANGANESE, BY COUNTRY OF ORIGIN

Long Tons

Year	Total	France	Germany	Yugoslavia	United States	Other
1934	269	259	4	-	-	6
1935	42	9	8	-	-	25
1936	123	90	23	-	-	10
1937	12	-	-	-	-	12
1938	17	-	1	-	-	16
1939	53	-	<u>41</u>	-	-	53
1940	88	-	-	-	-	88
1941	5,564	-	5,310	-	-	254 <u>12</u>
1942	308	-	76	-	-	232
1943	12	-	12	-	-	-
1944	<u>13</u>	-	-	-	-	-
1945	<u>13</u>	-	-	-	-	-
1946	1,067	-	-	-	1,067	-
1947	199	-	-	-	-	199 <u>12</u>
1948	4,719	-	-	3,621	1,001	97
1949	2,939	-	-	1,433	1,494	12

1 Not reported separately; if any, included in "Other."

2 Switzerland.

3 Not available.

Source: Statistica del commercio speciale di importazione e di esportazione.

Table XVI-18. ITALY - EXPORTS OF FERROMANGANESE, BY COUNTRIES OF DESTINATION

Long Tons

Year	Total	Germany	Australia	United States	Other
1934	544	89	62	364	29
1935	736	12	-	529	195
1936	198	-	-	198	-
1937	99	35	-	64	-
1938	10	-	-	-	10
1939	-	-	-	-	-
1940	1	-	-	-	1
1941	1	1	-	-	-
1942	-	-	-	-	-
1943 <u>/1</u>	-	-	-	-	-
1944 <u>/2</u>	-	-	-	-	-
1945 <u>/2</u>	-	-	-	-	-
1946	-	-	-	-	-
1947	-	-	-	-	-
1948	-	-	-	-	-
1949	597	-	133	-	-
1950					464 <u>/3</u>
1951					
1952					

/1 January through June.

/2 Not available.

/3 Includes Austria, 41 tons; Czechoslovakia, 398 tons.

Sources: Statistica del commercio speciale di importazione e di esportazione.

EXPORTS OF FERROMANGANESE, BY COUNTRY OF DESTINATION

Long Tons

Page 1 of 2

Year	Total	Belgium-Lux.	Denmark	Finland	Germany	Switzerland	Sweden
1934	36,684	3,261	<u>/1</u>	<u>/1</u>	2,397	<u>/1</u>	3,303
1935	47,653	10,882	<u>/1</u>	<u>/1</u>	2,150	<u>/1</u>	2,472
1936	58,400	13,895	<u>/1</u>	<u>/1</u>	1,937	<u>/1</u>	3,393
1937	65,996	21,225	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>	4,703
1938	36,982 <u>/2</u>						
1939	66,332	30,356	734	856	111	98	3,606
1940	30,279	7,453	199	155	11,591	205	6,018
1941	14,564	<u>/1</u>	<u>/1</u>	219	13,704	<u>/1</u>	10
1942	1,550	-	-	-	1,550	-	-
1943	299	-	-	-	297	-	2
1944	1,225	-	-	-	1,225	-	-
1945	162	-	-	-	162	-	-
1946	13,178	3,945	238	305	<u>/1</u>	117	104
1947	31,761	16,273	346	<u>/1</u>	<u>/1</u>	<u>/1</u>	50
1948	58,133	30,783	557	55	<u>/1</u>	2,429	<u>/1</u>
1949	52,879	22,239	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>	<u>/1</u>
1950							
1951							
1952							

Table XVI-20. NORWAY - EXPORTS OF FERROMANGANESE, BY COUNTRY OF DESTINATION (Cont'd.)

## Long Tons

Year	United Kingdom	Australia	Br. India	United States	Argentina	Other
1934	679	2,716	<u>/1</u>	13,551	<u>/1</u>	10,777
1935	321	2,784	<u>/1</u>	18,881	<u>/1</u>	10,163
1936	729	2,561	<u>/1</u>	28,327	<u>/1</u>	7,558
1937	1,267	788	<u>/1</u>	22,115	<u>/1</u>	15,898
1938						
1939	1,629	-	203	22,807	219	5,713 <u>/3</u>
1940	521	-	100	3,842	-	195
1941	-	-	-	-	-	631
1942	-	-	-	-	-	-
1943	-	-	-	-	-	-
1944	-	-	-	-	-	-
1945	-	-	-	-	-	-
1946	-	-	-	-	105	10
1947	750	-	-	8,354	<u>/1</u>	693 <u>/4</u>
1948	296	-	-	13,649	<u>/1</u>	1,160 <u>/5</u>
1949	<u>/1</u>	-	-	22,853	<u>/1</u>	4,032
		-	-	26,608	<u>/1</u>	

/1 Not reported separately; if any, included in "Other."/2 Distribution by country is not available./3 Includes the following: Canada, 150 tons; Japan, 192 tons; France, 448 tons; Latvia, 348 tons; Poland and Danzig, 201 tons; Turkey, 448 tons./4 Includes the following: Eire, 38 tons; Netherlands, 45 tons; France, 600 tons./5 Includes the following: Netherlands, 502 tons; Czechoslovakia, 103 tons; Poland, 49 tons; Austria, 234 tons; Egypt, 100 tons.

Sources: Norges Handel, Imperial Institute and U. S. Foreign Service Reports.

**Table XVI-21. UNITED KINGDOM - IMPORTS OF FERROMANGANESE AND SPIEGELEISEN,  
BY COUNTRY OF ORIGIN**

Year	Long Tons								Other
	Total	Canada	Sweden	Norway	Belgium	France	Japan (incl. Formosa)	United States	
1934	2,402	5 /1	900	879	186	361	10	/2	61
1935	2,772	-	950	981	263	387	57	/3	134
1936	3,753	-	740	1,580	256	302	663	/3	212
1937	4,523	50 /1	693	2,138	147	584	664	/3	247
1938	2,878	25 /1	645	908	105	600	265	/3	330
1939	4,438	/2	618	1,720	107	1,272	-	/2	721
1940	4,458	662	/2	531	/2	1,164	/2	1,943	158
1941	2,428	2,423	-	-	-	-	-	5	-
1942	2,705	2,501	-	-	-	-	-	204	-
1943	3,888	2,887	-	-	-	-	-	1,001	-
1944	84	29	-	-	-	-	-	55	-
1945	-	-	-	-	-	-	-	-	-
1946	150	-	-	-	-	150	-	-	-
1947	1,685	1,034	-	651	-	-	-	-	-
1948	-	-	-	-	-	-	-	-	-
1949	-	-	-	-	-	-	-	--	-

/1 British countries.

/2 Not reported separately; if any, included in "Oster."

/3 Foreign Commerce and Navigation, Commerce Department, report the following United States exports: 1935, 47 tons; 1936, 240 tons; 1937, 300 tons; 1938, 1 ton; 1939, 18 tons; 1940, 479 tons.

Sources: Annual Statement of the Trade of the United Kingdom.

Table XVI-22. UNITED KINGDOM - IMPORTS OF SILICOMANGANESE

Long Tons

Year	Total	Canada	Sweden	Norway	Japan (including Formosa)	Other
1934	-	-	-	-	-	-
1935	8,937	-	2,273	6,234	421	9
1936	13,839	-	4,389	7,775	1,593	82
1937	17,122	300 <u>/1</u>	4,698	9,223	2,901	-
1938	9,186	-	2,904	5,419	671	192
1939	16,459	-	5,603	8,527	-	2,329
1940	14,703	7,690	-	5,383	-	1,630
1941	21,020	20,923	-	-	-	97
1942	7,715	7,715	-	-	-	-
1943	11,837	11,787	-	-	-	50 <u>/2</u>
1944	8,670	8,504	-	-	-	166 <u>/2</u>
1945	10,937	10,937	-	-	-	-
1946	7,325	6,525	-	800	-	-
1947	9,014	7,911	-	1,083	-	-
1948 <u>/4</u>	11,057					20 <u>/3</u>
1949 <u>/4</u>	9,100					

/1 British countries./2 United States/3 Union of South Africa/4 Distribution by country is not available.

Source: Annual Statement of the Trade of the United Kingdom.



Table XVI-23. UNITED KINGDOM - EXPORTS OF FERROMANGANESE AND SPIEGELEISEN, BY COUNTRY OF DESTINATION

Long Tons

Page 1 of 2

Year	Total	Br. India (incl. Burma)	Union of S. Africa & S.W. Af..Terr.	Australia	Canada	Other British	Belgium	Luxembourg	Czecho- slovakia	Finland
1934	8,964	/L	194	5,143	10	144	224	/L	/L	/L
1935	11,656	193	1,483	6,053	-	331	7	/L	/L	/L
1936	9,424	247	2,177	5,569	10	315	298	/L	/L	/L
1937	11,041	218	1,597	6,299	-	397	1,140	/L	/L	/L
1938	5,197	2,300	39	1,769	-	384	3	/L	/L	/L
1939	3,513	688	98	1,809	-	416	37	/L	/L	/L
1940	5,492	897	-	2,646	-	416	369	/L	/L	/L
1941	17,305	1,073	-	961	2,500	164	-	/L	/L	/L
1942	3,617	-	-	270	3,000	143	-	/L	/L	/L
1943	797	-	-	5	-	50	-	/L	/L	/L
1944	150	-	21	-	-	143	-	/L	/L	/L
1945	31,729	75	100	41	-	76	12,756	/L	/L	/L
1946	58,636	500	5	766	-	255	14,409	/L	/L	/L
1947	9,069	100	1	37	-	72	5,683	8,330	771	615
1948 /3	3,236							400	23	132
1949 /3	9,267									
1950										
1951										
1952										

Table XVI-23. UNITED KINGDOM - EXPORTS OF FERROMANGANESE AND SPIEGELEISEN,  
BY COUNTRY OF DESTINATION (Cont'd.)

Long Tons

Page 2 of 2

Year	France	Germany	Netherlands	Sweden	Switzerland	Turkey	Brazil	United States	Other
1934	-	55	/1	115	/1	/1	/1	2,750	329
1935	-	35	/1	125	/1	/1	/1	3,335	94
1936	30	26	/1	74	/1	/1	/1	-	678
1937	-	76	/1	178	/1	/1	/1	120	1,016
1938	-	55	-	-	/1	/1	/1	-	647
1939	-	-	-	-	/1	/1	/1	-	465
1940	-	-	-	-	/1	500	510	-	154
1941	-	-	-	-	/1	-	100	12,501	6
1942	-	-	-	-	/1	198	-	-	6
1943	-	-	-	-	/1	740	-	-	2
1944	-	-	-	-	/1	-	-	-	7
1945	16,455	-	30	1,085	20	500	/1	-	591
1946	23,385	-	1,628	5,457	1,572	453	/1	-	490
1947	1,800	-	115	30	24	-	/1	-	652
1948 /3									
1949 /3									

/1 Not reported separately; if any, included in "Other."

/2 Not reported separately; if any, included in "Other British."

/3 Distribution by country not available.

Source: Annual Statement of the Trade of the United Kingdom.

Table XVI-24. UNITED STATES - IMPORTS FOR CONSUMPTION OF FERROMANGANESE, BY COUNTRY OF ORIGIN

(Mn Content)

Long Tons

Year	Total	Canada	Norway	United Kingdom	Netherlands	France	Czechoslovakia	Poland and Danzig	Japan	India	Other
1934	18,702	2,226	12,387	2,041	258	440	-	734	-	-	616
1935	21,829	40	14,365	2,347	1,095	2,091	-	157	-	-	1,734
1936	30,594	1	20,655	478	4,347	2,151	557	1,997	257	-	151
1937	23,888	3,385	17,468	128	282	760	944	156	722	-	43
1938	21,118	-	10,547	-	5,843	1,137	3,043	-	308	-	240
1939	33,414	/1	19,563	-	7,974	846	2,050	1,598	-	-	1,383
1940	8,573	-	8,538	-	-	-	-	-	35	-	0
1941	5,086	1,073	12	4,001	-	-	-	-	-	-	0
1942	10,388	4,500	-	5,888	-	-	-	-	-	-	0
1943	884	-	-	-	-	-	-	-	-	884	0
1944	2,954	1,993	-	-	-	-	-	-	-	961	0
1945	24,727	24,727	-	-	-	-	-	-	-	-	0
1946	23,132	16,351	6,781	-	-	-	-	-	-	-	0
1947	58,197	48,936	9,261	-	-	-	-	-	-	-	0
1948	70,023	51,319	18,704	-	-	-	-	-	-	-	0
1949	46,578	23,021	23,500	-	-	-	-	-	11	-	46
1950											
1951											
1952											

/1 Less than 1 ton.

Source: Minerals Yearbook. Bureau of Mines, U. S. Department of Interior.

Table XVI-25. UNITED STATES - FOREIGN TRADE IN FERROMANGANESE AND SPIEGELEISEN

(Gross Weight)  
Long Tons

Year	Total	Imports for consumption					Total spiegel- eisen	Total exports
		Ferromanganese						
		Canada	Norway	United Kingdom	India	Other		
1934	23,349						21,164	222 /1
1935	27,240						32,384	131 /1
1936	37,953						52,011	466 /1
1937	29,559						16,841	1,725 /1
1938	26,258						17,248	247 /1
1939	41,227						38,264	2,923 /1
1940	10,369						15,585	13,036 /1
1941	6,278						4,233	4,603 /1
1942	13,189	5,761	-	7,428	-	-	1,777	6,397
1943	2,055	-	-	-	2,055	-	2,905	11,170
1944	3,749	2,492	-	-	1,257	-	3,358	536
1945	31,715	31,715	-	-	-	-	2,809	746
1946	28,687	20,333	8,354	-	-	-	287	2,635
1947	72,595	61,339	11,256	-	-	-	-	18,007
1948	87,696	64,567	23,129	-	-	-	-	17,586
1949	58,048	29,041	28,935	-	-	72	1,551	5,917

/1 Includes spiegeleisen, not separately classified before July 1, 1941.

Source: Minerals Yearbook, Bureau of Mines, U. S. Department of Interior.

Table XVI-26. PRODUCTION OF STEEL, BY COUNTRIES

Page 1 of 2

Short Tons

Year	United States	Canada	United Kingdom	Belgium	Luxembourg	Hungary	France	Italy	Russia
1951 /1	105,105,454	3,581,500	17,509,678	5,610,282	3,390,854	1,359,868	10,834,864	3,297,184	34,492,600
1950	96,808,496	3,383,140	18,243,610	4,174,376	2,698,798	1,126,244	9,534,504	2,602,924	29,754,000
1949	77,955,480	3,189,188	17,414,906	4,241,598	2,503,744	935,598	10,116,360	2,264,610	25,346,000
1948	88,640,470	3,158,828	16,662,240	4,317,709	2,703,942	818,300	7,983,959	2,342,498	22,200,000
1947	84,894,071	2,901,670	14,246,400	3,179,728	1,888,306	657,853	6,338,225	1,874,000	22,000,000
1946	66,602,724	2,293,005	14,219,520	2,517,653	1,426,376	388,891	4,858,938	1,269,850	20,000,000
1945	79,701,648	2,803,097	13,243,328	812,395	291,007	141,535	1,822,077	436,511	19,800,000
1944	89,641,600	2,930,174	13,599,264	701,063	1,388,898	765,878	3,408,311	1,137,574	15,400,000
1943	88,641,600	2,872,489	14,594,944	1,838,636	2,367,740	855,826	5,651,492	1,904,774	13,300,000
1942	86,031,931	2,986,170	14,494,704	1,521,174	1,719,588	865,085	4,947,122	2,129,644	12,200,000
1941	82,839,259	2,622,543	13,789,664	1,785,726	1,375,670	861,117	4,750,913	2,275,147	16,600,000
1940	66,982,686	2,173,887	14,526,736	2,089,960	1,137,574	826,725	4,864,450	2,486,789	20,100,000
1939	52,798,714	1,509,480	14,807,856	3,428,726	1,931,230	808,206	8,763,285	2,513,244	20,719,000
1938	31,751,990	1,262,880	11,645,648	2,518,898	1,583,549	703,263	6,805,985	2,559,685	20,335,276
1937	56,636,945	1,514,626	14,542,080	4,265,246	2,767,187	733,071	8,730,801	2,300,525	19,649,055
1936	53,499,999	1,207,230	13,198,752	3,492,691	2,183,839	609,606	7,394,751	2,232,283	18,013,072
1935	38,183,705	1,024,892	11,041,744	3,331,934	2,024,854	491,775	6,919,280	2,435,118	13,720,000
1934	29,181,924	830,398	9,911,664	3,248,297	2,130,191	347,630	6,805,985	2,019,908	10,543,985
1933	26,020,229	450,830	7,866,880	3,010,981	2,033,673	250,966	7,199,417	1,952,433	7,541,921
1932	15,322,901	375,624	5,892,768	3,075,348	2,155,751	198,249	6,217,360	1,539,095	6,393,700

Table XVI-26. PRODUCTION OF STEEL, BY COUNTRIES (Cont'd.)

Page 2 of 2

Short Tons

Year	Germany	Saar	Austria	Czecho- slovakia	Poland	Spain	Sweden	Japan	Total
1951	14,883,612	2,868,506	1,132,856	3,649,824	3,076,784	894,824	1,680,550	7,163,000	220,532,240
1950	13,357,342	2,089,392	1,043,594	3,015,072	N.A.	858,458	1,584,676	5,342,496	195,617,122
1949	10,089,912	1,936,214	920,170	2,766,020	2,540,110	718,504	1,509,740	3,428,322	167,876,476
1948	<u>13</u> 6,126,583	1,345,908	714,400	2,915,600	2,070,100	590,256	1,384,489	1,889,342	165,864,624
1947	<u>13</u> 3,290,366	776,019	394,293	2,519,858	1,730,611	581,132	1,310,635	1,040,571	149,623,738
1946	<u>13</u> 2,962,982	320,769	206,681	1,843,046	1,343,704	655,868	1,334,885	608,470	122,853,362
1945	<u>13</u> 321,872	.....	189,155	1,044,980	545,670	617,308	1,326,560	1,177,256	124,274,399
1944	20,191,930	1,974,220	.....	2,777,796	755,000	545,935	1,319,936	7,031,572	163,569,151
1943	22,011,800	2,635,600	.....	2,830,706	869,700	720,561	1,338,189	9,675,989	172,304,958
1942	22,575,100	3,226,430	.....	2,619,065	.....	662,820	1,353,643	8,759,978	166,092,454
1941	22,967,520	2,551,820	.....	2,658,748	.....	633,056	1,274,696	8,348,820	165,334,699
1940	21,099,120	1,231,270	.....	2,605,837	1,600,000	765,955	1,280,000	8,288,194	152,059,183
1939	24,810,570	2,222,240	.....	2,526,472	1,790,000	644,041	1,269,755	8,123,951	148,666,770
1938	24,973,700	2,800,940	.....	1,941,260	1,699,843	632,202	1,079,213	7,936,560	120,230,892
1937	19,316,643	2,563,950	716,224	2,555,276	1,600,261	183,574	1,218,772	6,405,827	145,700,063
1936	18,139,202	2,536,390	461,226	1,718,976	1,257,271	410,849	1,077,403	5,538,268	132,971,808
1935	15,419,589	2,323,650	401,255	1,262,238	1,041,279	645,985	988,151	5,442,172	106,697,621
1934	13,148,719	2,150,067	340,858	1,004,379	930,394	713,070	950,002	4,302,759	88,560,230
1933	8,390,948	1,847,859	248,909	775,600	900,684	558,515	694,335	3,531,289	73,275,469
1932	6,360,745	1,613,229	225,602	753,032	607,121	586,901	582,354	2,643,776	54,543,566

(1) Figures from secondary source.

(2) American, British, and French zones.

(3) Home Islands, Korea, and Manchuria in 1944 and previous years.

N.A. Not Available



## XVII. TARIFFS





## CHAPTER XVII TARIFFS

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## CHAPTER XVII TARIFFS

### A. SPIEGELEISEN (PAR. 301)

Table XVII-1. CHANGES IN UNITED STATES RATES OF DUTY

(Per long ton)

Item	Act of 1922	Act of 1930	1945	1948
Par. 301: Spiegeleisen containing more than 1 per centum of carbon -----	<u>Cents</u>  75	<u>Cents</u>  75	<u>Cents</u>  <u>1</u> 75	<u>Cents</u>  <u>2</u> 75

1 Bound, trade agreement with Canada, effective January 1939.

2 Bound, Geneva, 1948.

Note. Spiegeleisen containing certain alloys is subject to additional duty on alloy content in excess of specified amounts (see separate summary on alloyed products subject to additional duties on alloy content, par. 301). Virtually all imports of spiegeleisen contain no dutiable alloy.

Ad valorem equivalents of the duty. The ad valorem equivalent of the 1945 and 1948 rate of duty on spiegeleisen is 2.2 percent based on import values in 1939, and 1.4 percent based upon import values in 1946.

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Alloys of one or more of the metals barium, baron, calcium, columbium (or niobium), strontium, tantalum, thorium, titanium, uranium, vanadium, and zirconium, with one or more of the metals, aluminum, chromium, cobalt, copper, manganese, nickel, or silicon: United States imports for consumption, by principal sources, in specified years, 1937-44 - Table XVII-21...	32
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## CHAPTER XVII TARIFFS

### A. SPIEGELEISEN (PAR. 301)

Table XVII-1. CHANGES IN UNITED STATES RATES OF DUTY

(Per long ton)

Item	Act of 1922	Act of 1930	1945	1948
Par. 301: Spiegeleisen containing more than 1 per centum of carbon -----	<u>Cents</u>  75	<u>Cents</u>  75	<u>Cents</u>  <u>1</u> 75	<u>Cents</u>  <u>2</u> 75

1 Bound, trade agreement with Canada, effective January 1939.

2 Bound, Geneva, 1948.

Note. Spiegeleisen containing certain alloys is subject to additional duty on alloy content in excess of specified amounts (see separate summary on alloyed products subject to additional duties on alloy content, par. 301). Virtually all imports of spiegeleisen contain no dutiable alloy.

Ad valorem equivalents of the duty. The ad valorem equivalent of the 1945 and 1948 rate of duty on spiegeleisen is 2.2 percent based on import values in 1939, and 1.4 percent based upon import values in 1946.





Ad valorem equivalents of the duties. Imports have been too small and sporadic to permit the determination of representative ad valorem equivalents of the rates of duty.

C. MANGANESE ORE, FERRUGINOUS (CONTAINING OVER 10 BUT LESS THAN 35 PERCENT MANGANESE)

(PAR. 302 (a) )

Table XVII-4. CHANGES IN UNITED STATES RATES OF DUTY

(Cents per pound /1 of metallic manganese content)

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (a) : Manganese ore (including ferruginous manganese ore) or concentrates, and manganiferous iron ore, all the foregoing containing more than 10 percent but less than 35 percent of metallic manganese -----	1 <u>/2</u>	1	1/2 <u>/3</u>	1/4 <u>/4</u>

/1 The rate of 1 cent per pound is equal to \$22.40 per long ton of manganese content; the rate of 1/2 cent per pound, to \$11.20 per long ton; and the rate of 1/4 cent per pound to \$5.60 per long ton.

/2 If containing 30 percent or less of metallic manganese, free of duty under the Tariff Act of 1922.

/3 Trade agreement with Brazil, effective January 1936.

/4 Geneva, 1948.

Ad valorem equivalents of the duties. The ad valorem equivalent of the 1945 rate of duty on manganese ore containing over 10 but less than 35 percent manganese is 76.7 percent based on import values in 1939. The ad valorem equivalent of the 1948 rate of duty is 38.3 percent based on import values in 1939. There were no imports in 1946.

Table XVII-2. SPIEGELEISEN: UNITED STATES PRODUCTION, EXPORTS, AND IMPORTS (TOTAL AND BY PRINCIPAL SOURCES), IN SPECIFIED YEARS, 1937-47.

Long Tons

Year	Production /1	Domestic exports /2	Imports for consumption			
			All countries	Canada	Norway	Netherlands
1937	134,983	1,725	16,841	15,466	1,375	--
1938	24,939	247	17,248	16,783	400	65
1939	84,739	2,943	38,264	37,470	750	44
1943	134,071	/3 280	2,905	2,905	--	--
1946 /4	102,679	6,780	321	321	--	--
1947 /4	/5	272	/6	--	--	--

/1 Tons shipped, spiegeleisen not containing dutiable alloy only.

/2 Data for 1937-39 cover exports of both spiegeleisen (exports of which were small) and ferromanganese.

/3 Includes 255 tons, valued at \$9,223, exported under lend lease.

/4 Preliminary. /5 Not available. /6 None.

Source: Production, statistics of the Bureau of Mines; exports and imports, official statistics of the U. S. Department of Commerce.

Note. Based on quantity, imports ranged from 13 to 69 percent of production in the years 1935-39; during and since the war they did not exceed a few percent of production in any year. Exports were not separately classified before 1942 but were known to be negligible in prewar years; they reached a peak in 1946, when they represented about 6.5 percent of production.

#### Comment

The subject of this summary is spiegeleisen containing more than 1 percent of carbon. Spiegeleisen with a lower carbon content is treated under paragraph 302 (e).

manganese, and carbon. That is made in two standard

alloys: one 10 to 19 percent manganese, and the other, 19 to 21 percent. In the United States these alloys are produced in blast

furnaces. One large domestic producer uses an iron-zinc-manganese ore as the raw material, first extracting the zinc and then charging the residual material into the blast furnace along with coke, flux, and iron and steel scrap. Other producers may use either low-grade manganese ore (par. 302 (a) ) or manganiferous iron ore (par. 1700).

Spiegeleisen is used in both the open-hearth furnace and the Bessemer converter, where its deoxidizing properties aid in the production of clean steels. In the open-hearth furnace the alloy is often charged with scrap and pig iron to increase the residual manganese content of the steel. In the Bessemer converter spiegeleisen is added after the blow to obtain the desired manganese content as well as to recarburize the steel. Spiegeleisen is also used in the manufacture of gray and malleable iron. To a limited degree it can be used as a substitute for ferromanganese (par. 302 (d) ). In 1946, 0.5 pound of metallic manganese in the form of spiegeleisen was required per ton of steel produced; in 1945, 0.6 pound per ton was used.

In recent years United States production of spiegeleisen has come from three to five plants. Except for one major and one minor producer, the plants are operated by companies in the steel industry. Total output in 1937 amounted to 134,983 long tons. The following year, when domestic steel production was 44 percent below 1937, spiegeleisen shipments fell 82 percent. This substantial drop in shipments of spiegeleisen was due to a number of factors, including the lower operating rate of the steel industry, large stocks on hand, and the substitution of ferromanganese. In 1939, shipments of spiegeleisen rose to 84,739 long tons and subsequently increased substantially in the war years. The 1946 output of 102,679 tons came from three plants.

During 1935-39 imports on the average supplied about 26 percent of the spiegeleisen used in the United States and came mainly from Canada; minor quantities came from Norway. From 1940 to 1946 imports were at a very low rate compared with prewar years, the Canadian material no doubt going into the Canadian steel industry. The material imported under this paragraph is manufactured in electric furnaces and has a lower carbon content than the domestic blast-furnace product.

Before 1942 exports of spiegeleisen were not separately classified but were known to be small. In 1942 only 52 tons were exported, shipments being almost equally divided between Argentina and the Netherlands Indies. By 1946 exports had increased to 6,780 tons, and consisted largely of shipments to European nations. Exports were very small in 1947.

B. ALLOYED PRODUCTS SUBJECT TO ADDITIONAL  
DUTIES ON ALLOY CONTENT

(PAR. 301)

Table XVII-3. CHANGES IN UNITED STATES RATES OF DUTY

(Per pound of alloy content /1 )

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945 <u>/2</u>	1948 <u>/2</u>
Par. 301:				
Alloy content of iron in pigs and iron kentledge, spiegel- eisen containing more than 1 per centum of carbon, granular or sponge iron, wrought and cast scrap iron, scrap steel, hammer scale, roll scale, and mill scale:				
Vanadium content in excess of 0.1 percent -----	<u>/3</u>	\$1	\$1	50¢. <u>/4</u>
Tungsten content in excess of 0.2 percent -----	<u>/3</u>	72¢	72¢	50¢. <u>/4</u>
Molybdenum content in excess of 0.2 percent -----	<u>/3</u>	65¢	65¢	65¢. <u>/5</u>
Chromium content in excess of 0.2 percent -----	<u>/3</u>	3¢	3¢	1-1/2¢. <u>/4</u>

- /1 The rates shown are additional to base rates on products enumerated.
- /2 All duties on scrap suspended, effective March 14, 1942, to June 30, 1949, inclusive (Public Law 497, 77th Cong., and Public Laws 384 and 613, 80th Cong.).
- /3 No corresponding provision. No additional duty.
- /4 Geneva, 1948; rate not made effective on January 1, 1948, pursuant to article 27 of the Geneva agreement, but became effective July 11, 1948. The reduced rates do not apply to alloy content of granular or sponge iron which remains dutiable at the 1945 rates.
- /5 Bound, Geneva, 1948; binding not made effective on January 1, 1948, pursuant to article 27 of the Geneva agreement, but became effective July 11, 1948. Binding does not apply to granular or sponge iron.

Ad valorem equivalents of the duties. Imports have been too small and sporadic to permit the determination of representative ad valorem equivalents of the rates of duty.

C. MANGANESE ORE, FERRUGINOUS (CONTAINING OVER 10 BUT LESS THAN 35 PERCENT MANGANESE)

(PAR. 302 (a) )

Table XVII-4. CHANGES IN UNITED STATES RATES OF DUTY

(Cents per pound /1 of metallic manganese content)

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (a) : Manganese ore (including ferruginous manganese ore) or concentrates, and manganiferous iron ore, all the foregoing containing more than 10 percent but less than 35 percent of metallic manganese -----	1 <u>/2</u>	1	1/2 <u>/3</u>	1/4 <u>/4</u>

/1 The rate of 1 cent per pound is equal to \$22.40 per long ton of manganese content; the rate of 1/2 cent per pound, to \$11.20 per long ton; and the rate of 1/4 cent per pound to \$5.60 per long ton.

/2 If containing 30 percent or less of metallic manganese, free of duty under the Tariff Act of 1922.

/3 Trade agreement with Brazil, effective January 1936.

/4 Geneva, 1948.

Ad valorem equivalents of the duties. The ad valorem equivalent of the 1945 rate of duty on manganese ore containing over 10 but less than 35 percent manganese is 76.7 percent based on import values in 1939. The ad valorem equivalent of the 1948 rate of duty is 38.3 percent based on import values in 1939. There were no imports in 1946.

Table XVII-5. MANGANESE ORE, FERRUGINOUS (CONTAINING OVER 10 BUT LESS THAN 35 PERCENT MANGANESE) : UNITED STATES PRODUCTION AND IMPORTS (TOTAL AND BY PRINCIPAL SOURCES), IN SPECIFIED YEARS, 1937-47.

Year	Production <u>/1</u>	Imports for consumption			
		All countries	Union of South Africa	Egypt	Philippine Republic <u>/2</u>
1937	151,955	62,510	16,660	45,600	250
1938	33,620	30,050	30,050	-----	---
1939	239,544	30,684	30,684	-----	---
1943	418,627	9,953 <u>/3</u>	-----	9,899	---
1946 <u>/4</u>	89,659	-----	-----	-----	---
1947 <u>/4</u>	<u>/5</u>	9,580	-----	9,534	---
Quantity (long tons, manganese content)					
1937	<u>/5</u>	18,281	4,831	13,384	65
1938	<u>/5</u>	8,689	8,689	-----	---
1939	<u>/5</u>	8,898	8,898	-----	---
1943	60,215	2,886	-----	2,871	---
1946 <u>/4</u>	13,876	-----	-----	-----	---
1947 <u>/4</u>	<u>/5</u>	2,790	-----	2,767	---

/1 Shipments from mines.

/2 Free of duty.

/3 Includes 9,923 long tons, valued at \$126,841, imported free of duty for U. S. Government use.

/4 Preliminary.

/5 Not available.

Source: Production, official statistics of the Bureau of Mines; imports, official statistics of the U. S. Department of Commerce.

Note. There are no exports of manganese ore except possible small lots occasionally shipped to Canada.

#### Comment

This summary covers ferruginous manganese ore (containing more than 10 percent but less than 35 percent manganese), which is an intimate mixture of oxides of iron and manganese and is used in manufacturing spiegeleisen in blast furnaces. It is not to be confused with

manganese ore containing over 35 percent manganese (see separate summary, par. 302 (a) ), a much more important material, of which the imports greatly exceed the domestic production.

The United States has large reserves of ore of the grade covered by this summary and is the world's largest producer and consumer. The output averaged about 142,000 long tons annually in 1937-39 and increased to an annual average of about 392,000 long tons in 1940-43 to meet wartime requirements. It declined rapidly thereafter and in 1946 amounted only to about 90,000 long tons, with an average manganese content of about 15 percent (see table 5). The ore is mined in about a dozen widely scattered states, Minnesota being the largest and New Mexico the most consistent producer. Other important sources of the ore are Montana and Georgia.

There are no known exports of ferruginous manganese ore, although occasional small shipments may have been made to Canada.

There were no imports of this type of ore until the duty was reduced in 1936, in the trade agreement with Brazil, from 1 cent to 1/2 cent per pound of metallic manganese content. Small shipments were received from Egypt in that year; thereafter the Union of South Africa became the major source. Imports were small during the war years and subsequently; there were none in 1946 and only small quantities imported in 1947.

In the Geneva agreement the rate of duty on ferruginous manganese ore was reduced from 1/2 to 1/4 cent per pound of metallic manganese content.



D. MANGANESE ORE, FERRO AND CHEMICAL GRADE (CONTAINING  
35 PERCENT OR MORE MANGANESE)

(PAR. 302 (a) )

Table XVII-6. CHANGES IN UNITED STATES RATES  
OF DUTY

(Cents per pound /1 of metallic manganese content)

Item	Tariff rate in -			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (a): Manganese ore (including ferrugi- nous manganese ore) or concent- rates, and manganiferous iron ore, all the foregoing contain- ing 35 percent or more of metallic manganese:				
Product of Cuba -----	Free	Free	Free <u>/2</u>	Free <u>/3</u>
Other than product of Cuba-----	1¢	1¢	1/2¢ <u>/4</u>	1/4 ¢ <u>/5</u>

/1 Rate of 1 cent per pound is equal to \$22.40 per long ton; rate of 1/2 cent per pound, to \$11.20 per long ton; and rate of 1/4 cent per pound, to \$5.60 per long ton.

/2 Bound free in trade agreement with Cuba, effective September 1934.

/3 Bound free in exclusive agreement with Cuba, Geneva, 1948.

/4 Trade agreement with Brazil, effective January 1936.

/5 Geneva, 1948.

Ad valorem equivalent of the duty. The ad valorem equivalent of the 1945 rate of duty on manganese ore is 43.1 percent based on import values in 1939 and 35.4 percent based on import values in 1946. The ad valorem equivalent of the 1948 rate is 21.5 percent based on import values in 1939 and 17.7 percent based on import values in 1946.

Table XVII-7. MANGANESE ORE, MANGANESE CONTENT 35 PERCENT AND OVER: UNITED STATES PRODUCTION, AND IMPORTS (TOTAL AND BY PRINCIPAL SOURCE), IN SPECIFIED YEARS, 1931-47.

Year	Production (ship- ments)	Imports for consumption						
		All countries	Gold Coast	Soviet Union	India	Brazil	Cuba	All other
Quantity in gross weight (1, 000 long tons)								
1931	39	502	87	196	48 <u>/1</u>	134	4	33
1935	26	384	95	153	57 <u>/1</u>	30	44	5
1937	40	912	255	384	70 <u>/1</u>	78	123	2
1938	25	484	127	166	25	30	131	5
1939	29	627	243	135	90	43	106	10
1943	183	1,350 <u>/2</u>	194	4	413	333	189	217
1946 <u>/3</u>	129	1,355 <u>/2</u>	253	216	287	77	142	380
1947 <u>/3</u>	132	1,159 <u>/2</u>	195	258	254	141	51	260
Quantity in manganese content (1, 000 long tons)								
1931	<u>/4</u>	246	44	99	25 <u>/1</u>	59	1	18
1935	<u>/4</u>	189	49	73	28 <u>/1</u>	13	22	4
1937	<u>/4</u>	446	130	187	37 <u>/1</u>	36	56	<u>/5</u>
1938	<u>/4</u>	234	64	81	13	13	62	1
1939	<u>/4</u>	314	123	69	46	19	52	5
1943	98	651	101	2	210	150	91	97
1946 <u>/3</u>	75	662	130	109	144	35	69	175
1947 <u>/3</u>	77	558	100	131	125	63	24	115

/1 Includes Burma.

/2 Includes imports free of duty for U. S. Government use as follows:

	Long Tons
1943-----	400,000
1946-----	334,307
1947-----	159,391

/3 Preliminary.

/4 Not available.

/5 Less than 500.

Source: Production, from statistics of the Bureau of Mines; imports from official statistics of the U. S. Department of Commerce.

Note. Exports not separately reported before 1942 (see text).

### Comment

Description and Uses. This summary deals with manganese ore or concentrates containing 35 percent or more metallic manganese. Such ore is generally what is meant by the term "manganese ore," and it is usually classified into two distinct types: Metallurgical ore and battery or chemical ore. The first type, which contains at least 35 percent manganese and preferably about 50 percent, is used in making ferromanganese and electrolytic metallic manganese, both consumed by the steel industry, with some metallic manganese used in nonferrous alloys. Battery or chemical ore must likewise have a high manganese content, but it must possess other important physical properties as well. Manganese ore for battery use should have a high content of available oxygen, contain a minimum of iron, and be relatively free from such metals as arsenic, copper, nickel, and cobalt, which are electronegative to zinc. Chemical ore has a wide range of analyses. In 1943, about 96 percent of all manganese ore consumed in the United States was absorbed by the steel industry; nearly all the rest was battery or chemical ore.

United States Production. Generally speaking, in peacetime the domestic manganese industry is relatively small. During the years 1910-14 the annual domestic output averaged 2,600 long tons (gross weight) of manganese ore, supplying only about 1 percent of domestic consumption. In response to the heavy demand during World War I, production in 1918 reached an all-time annual record of 306,000 long tons which represented over one-third of domestic consumption in that year. By 1922, however, the output had receded to 13,000 tons, and it averaged about 51,000 long tons annually for the 1920-29 period. During the 1930's domestic production ranged from 18,000 long tons (1932) to 67,000 long tons (1930) annually and averaged about 32,000 tons annually for the decade. According to the Bureau of the Census, in 1939 there were 24 manganese mines in operation with a total employment of 557 persons. During World War II the premium prices paid by the Government and other Government assistance to manganese producers greatly stimulated production, which reached a peak of 221,000 long tons of manganese ore and concentrates in 1944 and averaged 163,000 long tons annually for 1941-45. Most of the increased production consisted of ore or concentrates of metallurgical grade. In 1946 and 1947 output averaged about 130,000 tons (gross weight)

annually. This was still high in comparison with the average for the two decades before World War II, but it represented a decline of about 20 percent from the 1941-45 average.

Metallurgical ore is produced in about 12 states, Montana alone producing over half of the total output. Montana is also the principal, and in some years the only, source of battery ore.

The metallurgical ore in Montana is mostly carbonate ore, which is concentrated and sintered to form an oxide, whereas most of the battery ore is natural oxide ore. Both of these Montana ores have substantially higher manganese content than ore commercially mined in other states.

United States imports and exports. Imports have always supplied a very large part (normally over 90 percent) of the United States consumption of manganese ore, and this dependence on foreign sources is particularly important with reference to metallurgical ore, owing to the large quantity required. Even during the recent war, when intensive efforts brought about a large increase in domestic production, imports still supplied about 85 percent of consumption. Battery ore constitutes only a small part of total imports (see table 8), and imports normally supply a substantially smaller proportion of domestic consumption of such ore than of the metallurgical ore.

Table XVII-8. MANGANESE ORE - MANGANESE CONTENT 35 PERCENT AND OVER: UNITED STATES IMPORTS FOR CONSUMPTION, BY KINDS, WITH PRINCIPAL SOURCES, 1940 AND 1946.

(Quantity in long tons, gross weight)

Kind	Quantity	Foreign value	
		Total	By principal sources
1940 /1			
Battery grade----	27,410	\$ 596,442	Gold Coast, \$492,479; Union of South Africa, \$56,030; India, \$41,952.
Other than battery grade:			
Free-----	174,188	3,686,978	Cuba, \$3,059,735; Philippine Republic, \$627,243.
Dutiable-----	1,080,686	13,948,467	Gold Coast, \$3,975,904; Soviet Union, \$3,947,766; India, \$2,281,928; Union of South Africa, \$1,746,507; Brazil, \$1,678,395.
1946 /2			
Battery grade:			
Free /3 -----	28,645	\$ 900,091	Soviet Union, \$900,091.
Dutiable -----	47,780	969,687	Gold Coast, \$739,577; Soviet Union, \$130,862; Mexico \$60,567; India, \$37,507.
Other than battery grade:			
Free /4 -----	3,053	43,918	Gold Coast, \$43,918.
Free /5 -----	141,727	3,868,372	Cuba, \$3,868,372.
Free /3 -----	305,662	11,263,473	Soviet Union \$6,939,106; Chile, \$4,219,373; Brazil, \$104,994.
Dutiable-----	828,458	12,656,000	Union of South Africa \$3,988,310; India and Dependencies, \$3,809,877; Gold Coast, \$2,351,792; Mexico, \$943,447; Soviet Union, \$273,018.

- /1 New classification established January 1, 1940.
- /2 Preliminary.
- /3 Free of duty for U.S. Government Use.
- /4 Free for manufacture in bonded warehouse and export.
- /5 Imports from Cuba enter free of duty under commercial agreements between the United States and Cuba.

Source: Official statistics of the U. S. Department of Commerce.

Statistics of imports before June 18, 1930 (under the Tariff Act of 1922), are not comparable with those for subsequent years (under the Tariff Act of 1930). In 1931-39, imports ranged from about 91,000 long tons (gross weight) in 1932 to about 912,000 long tons (gross weight) in 1937 and averaged about 485,000 long tons (gross weight), with a manganese content of 49 percent, annually for the period. During the war they increased very substantially, reaching a high of 1,531,000 long tons (gross weight, with about 737,000 long tons of manganese content) in 1941. During 1942-46, annual imports averaged about 1,292,000 long tons with a metal content of 625,000 long tons and an average ore grade of 48.4 percent. In the same period domestic production, some of which was concentrated, averaged about 164,000 long tons with a metal content of 90,000 long tons and ore grade of 54.9 percent.

Before the war imports of manganese ore came chiefly from the Gold Coast, Brazil, Cuba, /1 the Soviet Union, and India. During the war, transportation difficulties sharply curtailed imports from the Gold Coast and virtually stopped those from the Soviet Union. However, the greatly increased shipments from Brazil, India, and Cuba more than compensated for the losses from customary sources.

Since the end of the war, imports have continued higher than in prewar years and amounted in 1946 and 1947 to 1,355,000 and 1,159,000 long tons (gross weight), respectively. In 1947, 22.3 percent of total imports came from the Soviet Union; 21.9 percent from India; 16.8 percent from the Gold Coast; 12.1 percent from Brazil; and 7.5 percent from the Union of South Africa.

Manganese ore is one of the strategic and critical materials listed for stockpiling. The Bureau of Federal Supply of the Treasury Department, under direction of the Secretaries of War and Navy, was authorized under Public Law 520 (effective July 23, 1946) to make purchases for the stockpiling program. No statistical data have been published regarding the tonnages secured or expenditures under the stockpiling program.

United States exports of manganese ore were not separately reported in official statistics before 1942 but are known to have been negligible. They consisted mainly of specially prepared high-grade battery ores. From 1943 to 1947 exports ranged from 4,000 to 10,000 long tons (gross weight) annually.

Competitive Conditions. Since manganese is indispensable to the steel industry, which consumes a large quantity of high-grade metallurgical ore, the demand for manganese ore is governed almost entirely by the trend in steel production. However, the choice between domestic and imported ore of the same grade is normally determined by the price at which the two ores are available at a given time.

There are some 2,000 occurrences of manganese ore in the United States, but only a few deposits of ferro-grade ore can be worked without resorting to costly methods of beneficiation. Experience during the two wars indicates that, under wartime stress and when price is not a major consideration, it is possible to increase the domestic output of high-grade manganese ore. However, it does not seem possible to maintain subsequently the higher wartime level of production in competition with imported ores. Moreover, the increase in domestic production under favorable conditions has been very limited in terms of the long-term needs of domestic industry for high-grade ore; the larger output during World War II, for example, would supply only a small proportion of normal peacetime requirements. In addition, since the known reserves of the high-grade ores are not large and the present state of the arts does not permit the general substitution of the low-grade ores for the high-grade, a sustained high level of domestic production would hasten the exhaustion of the high-grade ores. Such a result would have to be considered in the light of national policy and interests, including national defense. In this connection, it is noted that manganese ore is designated as a "strategic and critical material" under the current stockpiling program of the United States Government.

United States reserves of low-grade manganese ores, which are not considered in this summary, are large and conceivably could meet domestic requirements for metallic manganese for several years. However, the cost of beneficiating such ores would be high and it appears improbable that, with present technology, the product would be competitive with imported ore. On the basis of the war experience and the possibility of substituting low-grade ores for the type covered by this summary, the United States Geological Survey and United States

Bureau of Mines have recently informed the Congress that in the future "domestic production can be expected to increase only to the degree that processes of extraction used under the high wartime price prove economic at lower price levels, and to the extent that processes for recovering the manganese from very low-grade material can be developed and applied at a cost comparable to the price of imported high-grade ores." /2

Compared with the high degree of dependence of the United States steel industry on imported metallurgical ore, the situation with regard to the battery or chemical grade is different. The demand for this grade of ore is relatively small in contrast with that for ferro-grade. Moreover, the known domestic reserves of battery or chemical ore are much larger in relation to domestic requirements than is true of metallurgical ore. Domestic production of battery ore is capable of filling all United States requirements, although, as noted previously, limited amounts of high-grade battery ore are also imported.

The rate of duty on manganese ore containing 35 percent or more of manganese was reduced from 1 cent to 1/2 cent per pound of contained metallic manganese in the trade agreement with Brazil, effective January 1936, and further reduced to 1/4 cent per pound of contained metallic manganese in the Geneva agreement.

/1 A considerable amount of United States capital is invested in manganese mining in these three countries.

/2 Investigation of National Resources, Hearings before a Subcommittee of the Committee on Public Lands, U. S. Senate, 80th Congress, 1st Session, 1947, p. 260.



# E. FERROMANGANESE

(PAR. 302 (d) (e) )

Table XVII-9. CHANGES IN UNITED STATES RATES OF DUTY

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (e): Ferromanganese: Containing not more than 1 percent of carbon.	Cents per pound of manganese content plus percent ad valorem			
	1-7/8¢ + 15%	1-7/8¢ + 15%	1-7/8¢ + 15%	15/16¢ + 10% <u>/1</u>
	Cents per pound of manganese content			
Par. 302 (d): Ferromanganese: Containing more than 1 per- cent and less than 4 per- cent or carbon -----	1-7/8¢	1-7/8¢	1-7/8¢	15/16¢. <u>/1</u>
	1-7/8¢	1-7/8¢	1¢ <u>/2</u>	11/16¢. <u>/3</u>

/1 Geneva, 1948; rate not made effective on Jan. 1, 1948, pursuant to article 27 of the Geneva agreement, but became effective July 11, 1948.

/2 Trade agreements with Canada effective January 1936 and January 1939. The rate specified in the agreements was 3/8 cent per pound of metallic manganese content plus 1-1/4 times the duty on manganese ore; since the 1945 rate on ore was 1/2 cent per pound of metallic manganese content (as fixed by the 1936 trade agreement with Brazil), the rate on this ferromanganese is equivalent to 1 cent per pound of metallic manganese content.

/3 Geneva, 1948.

Table XVII-10. FERROMANGANESE: AD VALOREM EQUIVALENTS OF 1945 AND 1948 RATES OF DUTY

Item	Ad valorem equivalent of-			
	1945 rate based on value of imports in-		1948 rate based on value of imports in-	
	1939	1946	1939	1946
	Percent	Percent	Percent	Percent
Ferromanganese containing				
Not over 1 percent carbon---	44.8	25.4	24.9	15.2
Containing over 1 percent and less than 4 percent carbon -----	35.9	15.5	18.0	7.8
Containing not less than 4 percent carbon-----	32.3	13.5	22.2	9.3

Table XVII-11. FERROMANGANESE: UNITED STATES PRODUCTION, EXPORTS, AND IMPORTS (TOTAL AND BY PRINCIPAL SOURCES), IN SPECIFIED YEARS, 1937-47.

Long Tons

Year	Production <u>/1</u>	Domestic exports <u>/2</u>	Imports for consumption				
			All countries	Norway	Nether-lands	Czecho-slovakia	Canada
1937	359,842	1,725	29,559	21,578	356	1,198	4,245
1938	223,720	247	26,258	13,068	7,332	3,850	-----
1939	296,631	2,923	41,227	23,943	9,933	2,594	<u>/3</u>
1943	645,334	11,169 <u>/4</u>	2,055 <u>/5</u>	---	---	---	-----
1946	440,971	2,635	28,687	8,355	---	---	20,332
1947	548,792	18,007	72,596	11,256	---	---	61,340

/1 Shipments.

/2 Includes spiegeleisen before 1943; in 1937-39 exports of spiegeleisen were small.

/3 Less than one-half long ton.

/4 Includes 4,849 long tons, valued at \$825,296, exported under lend lease.

/5 All from India, free of duty for United States Government use.

Source: Production, official statistics of the Bureau of Mines; exports and imports, official statistics of the U.S. Bureau of Commerce.

## Comment

Ferromanganese, an alloy of manganese and iron containing 78 to 82 percent manganese, is the standard form in which manganese is used by the steel industry. Manganese is used in making steel, not only to deoxidize and recarburize the molten metal, thus making possible the production of cleaner and sounder ingots containing the desired amount of carbon, but also to impart special qualities to the product. About 20 pounds of 80-percent ferromanganese are required for each ton of steel produced; on the basis of an annual steel production of 45 million tons of ingot, 450,000 tons of ferromanganese would be required. Ferromanganese is also used in making special steels in the open hearth, as a hardening agent in the aluminum industry, and as an alloying agent in some bronzes.

Ferromanganese is manufactured in the United States, principally from foreign manganese ore, and usually in a blast furnace, although it can be and some is made in electric furnaces. The blast furnace product is low in manganese and high in carbon, and the cost of plant upkeep is high. At least a dozen furnaces in the United States, located near the principal steel centers, are engaged in its production. Domestic production before the war normally supplied about 90 percent of domestic requirements, most of it being high-carbon material produced in the blast furnace. Hydroelectric developments since 1935 have made available large amounts of cheap electric current and have resulted in the conversion to rapid, efficient, and flexible electric furnaces.

The United States depends on imports of manganese, either in ore or as alloys, for most of its requirements, which are determined by the level of activity in the steel industry. Most of the manganese-bearing materials are imported in the form of ores rather than as alloys such as ferromanganese.

Imports of ferromanganese averaged about 30,000 long tons a year before World War II; Norway, France, the Netherlands, and Czechoslovakia were the principal source of these imports. With the advent of the war and the suspension of trade with these countries, imports declined sharply. In 1947, imports were more than twice the average prewar level (see table 11) with Canada supplying about 80 percent of the total and Norway the remainder. The increase in imports since the war can be attributed to the unprecedented demand for steel which has been placed upon the domestic industry. Ferromanganese containing more than 4 percent of carbon ordinarily constitutes most of the imports (see table 12).

Table XVII-12. FERROMANGANESE; UNITED STATES IMPORTS  
FOR CONSUMPTION, BY KINDS, WITH PRINCIPAL SOURCES,  
1939 AND 1946.

(Quantity in long tons; value in thousands of dollars)

Kind	Quantity	Foreign value	
		Total	By principal sources
	1939		
Ferromanganese containing -			
Not over 1 percent of	1,017	120	All from Norway
carbon -----			
1 to 4 percent of carbon	14,136	1,376	Norway, 1,280; France, 92; Sweden, 3.
Not less than 4 percent			
of carbon -----	26,074	1,440	Netherlands, 562; Norway, 510; Czechoslovakia, 162; Poland and Danzig, 118; Yugoslavia, 55; Germany, <u>1</u> 25; France, 8.
	1946 <u>2</u>		
Ferromanganese containing-			
Not over 1 percent of	46	15	All from Canada.
carbon-----			
1 to 4 percent of carbon	7,608	1,687	Norway, 1,378; Canada 309.
Not less than 4 percent			
of carbon -----	21,033	2,791	Canada, 2,583; Norway, 208.

1 Includes Austria.

2 Preliminary.

Source: Official statistics of the U.S. Department of Commerce.

Before 1943 exports of ferromanganese were combined with exports of spiegeleisen and therefore are not comparable to present statistics. During 1942 and 1943 exports of ferromanganese were heavy, going principally to Canada, for use in war industry expansion in that country. During 1944 and 1945 exports averaged about 600 tons per year, principally to Canada and South America. In 1946 Europe again entered the market and Italy and Canada were our principal

export markets. With the reconstruction program Europe, especially Belgium and France, imported large quantities of American ferromanganese during 1947. Future exports will naturally depend upon the rebuilding of European industries, and when this is accomplished domestic exports will probably be negligible compared to production.

In the Geneva agreement the duties on ferromanganese were reduced as indicated in table 8. Except for ferromanganese containing more than 1 percent and not more than 4 percent carbon, on which the duty was reduced 50 percent, the reductions were less than the reduction of 50 percent made on manganese ore in that agreement.

F. MANGANESE SILICON (INCLUDING SILICOMANGANESE)  
(PAR. 302 (e) )

Table XVII-13. CHANGES IN UNITED STATES RATES OF DUTY

(In cents per pound of manganese content plus percent ad valorem)

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (e):				
Manganese silicon:				
Containing not more than 45 percent of manganese.	1-7/8¢ + 15%	1-7/8¢ + 15%	1-7/8 ¢ + 15%	1-7/8¢ + 15%
Containing more than 45 percent of manganese.	1-7/8¢ + 15%	1-7/8¢ + 15%	1-7/8 ¢ + 15%	1¢ + 10% /1

/1 Geneva, 1948; rate note made effective on Jan. 1, 1948, pursuant to article 27 of the Geneva agreement, but became effective July 11, 1948.

Ad valorem equivalents of the duties. The ad valorem equivalent of the 1945 rate of duty on manganese silicon (including silico manganese) containing more than 45 percent manganese is 71.2 percent based on average import values in 1939 and 35.5 percent based on average import values in 1946. The ad valorem equivalent of the 1948 rate is 40.0 percent based on average import values in 1939 and 20.9 percent based on average import values in 1946.

There have been no recorded imports of manganese silicon containing not more than 45 percent manganese.

Table XVII-14. MANGANESE SILICON (INCLUDING SILICO-  
MANGANESE): UNITED STATES IMPORTS FOR CONSUMP-  
TION, /1 IN SPECIFIED YEARS, 1937-46. /2

(Quantity in pounds of manganese content)

Year	Quantity	Foreign value
1937	78,591	\$ 2,070
1939	37,172	1,240
1945	10,282	7,891
1946 /3	228,377	20,892

/1 All from Norway in 1937 and 1939; all from Canada in 1945 and 1946.

/2 There were no imports from 1940 to 1944 and none in 1947.

/3 Preliminary.

Source: Official statistics of the U.S. Department of Commerce.

Note. Domestic production is believed to be small, possibly 4,000 to 5,000 tons per year, but statistics are not available. Exports are not separately shown but are believed to be small or nil.

#### Comment

Manganese silicon is used by the steel industry for close control of the chemical and physical properties in certain high-grade steel demanded by exacting customers. When added in the proper amount to molten steel, it provides an economical and rapid method for removing harmful oxides and at the same time raises the manganese content of the steel. Silicon and manganese both have a strong affinity for oxygen; and, when they are introduced as alloys, the product of the reaction possesses more fluidity because of its lower melting point than when other alloys are used. This property of affinity is essential for the production of clean steel.

. In the United States manganese silicon is manufactured in the electric furnace from domestic materials. It is made by only a few operators. Production is small and unrecorded (possibly 4 to 5 thousand tons annually) but nevertheless greatly exceeds imports. According to the Federal Bureau of Mines, the domestic material produced in 1943 averaged 67 percent manganese. Imports have always been small, and Canada and Norway have been the sole suppliers. Export statistics are unavailable, but exports are believed to be small

or nil.

In the Geneva agreement the compound duty on manganese silicon containing more than 45 percent manganese was reduced from 1-7/8 to 1 cent per pound of manganese content and from 15 percent to 10 percent ad valorem and made effective on July 11, 1948. The duty on manganese silicon containing not more than 45 percent of manganese was not affected by the Geneva agreement. The duty on manganese ore was reduced from 1/2 cent per pound of manganese content to 1/4 cent per pound in the Geneva agreement (see summaries on manganese ore, par. 302 (a) ).

G. SPIEGELEISEN (CONTAINING NOT OVER 1 PERCENT CARBON),  
MANGANESE BORON, AND MANGANESE METAL  
(PAR. 302 (e) )

Table XVII-15. CHANGES IN UNITED STATES RATES OF DUTY

(In cents per pound manganese content plus percent ad valorem)

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302(e) : Spiegeleisen containing not more than 1 per centum of carbon, manganese boron, and manganese metal-----	1-7/8¢ +	1-7/8¢ +	1-7/8¢	1-7/8¢ +

Ad valorem equivalent of the duty. The ad valorem equivalent of the 1945 and 1948 rate of duty on spiegeleisen containing not over 1 percent carbon, manganese boron, and manganese metal is 24.8 percent, based on import values in 1939. Imports were too small in 1946 to afford an adequate basis of computation.

Table XVII-16. SPIEGELEISEN (CONTAINING NOT OVER 1 PERCENT CARBON), MANGANESE BORON, AND MANGANESE METAL; UNITED STATES EXPORTS, AND IMPORTS (TOTAL AND BY PRINCIPAL SOURCES), IN SPECIFIED YEARS, 1937-47.

(Quantity (pounds, manganese content))

Year	Domestic exports	Imports for consumption		
		All countries	France	United Kingdom
1937	<u>/1</u>	3,032	3,032	---
1938	<u>/1</u>	43,461	43,461	---
1939	<u>/1</u>	48,463	46,290	2,173
1943	1,008,925 <u>/2</u>	---	---	---
1946 <u>/3</u>	831,557	<u>/4</u>	---	<u>/4</u>
1947 <u>/3</u>	632,185	<u>/4</u>	---	<u>/4</u>

/1 Not available.

/2 Includes 880,194 pounds, valued at \$248,718, exported under lend lease.

/3 Preliminary.

/4 Less than 1 pound.

Source: Official statistics of the U. S. Department of Commerce.

Note. Production is not recorded. From the value of exports in 1943 and 1946, it appears that the domestic industry is capable of producing well over a million pounds of manganese metal, manganese boron, and low-carbon spiegeleisen.

#### Comment

The products covered by this summary are used as additives in ferrous and nonferrous metallurgy because of their chemical effects or alloying characteristics. Manganese metal is produced usually by electrolysis, and is made from ferrograde manganese ore, usually imported, or from ferruginous manganese ore. Manganese boron is produced in the electric furnace from ferrograde manganese ore. Low-carbon spiegeleisen is also an electric-furnace product, but there has been no known domestic production for many years. (For a discussion of manganese ores and the rates of duty applicable to them, see the summaries under par. 302 (a) ).



Spiegeleisen containing not over 1 percent is used to some extent in the manufacture of low-carbon steels. (For spiegeleisen with a higher carbon content, see the summary under par. 301.) Manganese boron is used in nonferrous metallurgy as a deoxidizer and degasifier and to impart a fine grain to several of the aluminum alloys; in ferrous metallurgy, it is used to increase the hardening depth of heat-treated engineering steels and to shorten the heat-treating cycle in production of malleable cast iron. Manganese metal is used to a limited extent in place of ferromanganese in the steel industry and to produce desired strength, ductility, and hot-rolling properties in certain nonferrous metals and alloys. The consumption of manganese metal is largest in the production of brass, bronze, and aluminum alloys. The largest domestic producer of manganese metal is in Tennessee, with a reported productive capacity of 275,000 pounds of electrolytic manganese metal per month. There are also four other producers of manganese metal and manganese boron.

Statistics on domestic output of the products covered by this summary are not available, but it is clear that the production of manganese metal and manganese boron taken together is ample to meet domestic requirements and to provide substantial exports exceeding 800,000 pounds both in 1943 and 1946. Exports, consisting chiefly of manganese boron and manganese metal, have gone mainly to the United Kingdom, Canada, Brazil, Sweden, Cuba, Mexico, and Chile.

United States imports, consisting principally of spiegeleisen, were relatively small before World War II and came mostly from France. During and since the war they have been virtually nil.

H. MANGANESE COPPER  
(PAR. 302 (1) )

Table XVII-17. CHANGES IN UNITED STATES RATES OF DUTY

(Percent ad valorem and cents per pound copper content)

Item	Tariff rate in-				Import-excise tax in-		
	Act of 1922	Act of 1930	1945	1948	Revenue Act of 1932 <u>/1</u>	1945	1948
Par. 302 (1): Manganese copper --	Free	25%	25%	25%	3¢	3¢	1-1/2 ¢

/1 Internal Revenue Code, sec. 3425.

/2 Geneva, 1948. Because of suspension of import- excise tax until April 1, 1949, (Public Law 42, 80th Cong.), this concession will have no effect until tax suspension terminates. The suspension of the import-excise tax was continued only until July 1, 1950, and is now in force.

Ad valorem equivalents of the duties. The ad valorem equivalent of the 1945 combined tariff rate and import-excise tax on the basis of import values in 1939 is 52.4 percent; on the same basis the ad valorem equivalent of the 1948 combined rate is 40.7 percent. No imports were recorded in 1946.

Table XVII-18. MANGANESE COPPER: UNITED STATES IMPORTS  
FOR CONSUMPTION, /1 BY PRINCIPAL SOURCES,  
IN SPECIFIED YEARS, 1937-43 /2

Year	Quantity
	Pounds
1937	9,806
1938	---
1939	26,364
1943	1,000 <u>/3</u>

/1 All from Norway, except as noted.

/2 There have been no imports since 1943.

/3 All from the United Kingdom, imported duty-free for U.S. Government use.

Source: Official statistics of the U.S. Department of Commerce.

Note. United States production is small and unrecorded. Exports are believed to be very small, but statistics are not available.

### Comment

Manganese copper is used in the production of copper-base alloys, principally nickel brass. These alloys are used in making large marine castings, such as propellers and valve stems. Manganese-copper alloy is usually manufactured in the electric furnace. The number of domestic producers is few, and the quantity of alloy produced is small and unrecorded (probably 40,000 to 50,000 pounds annually). Imports have generally been small and have usually come from Norway.

Export statistics are not available, but exports are believed to be small or nil.

### I. FERROALUMINUM VANADIUM, FERROMANGANESE VANADIUM, FERROSILICON VANADIUM, AND FERROSILICON-ALUMINUM VANADIUM (PAR. 302 (m) )

Table XVII-19. CHANGES IN UNITED STATES RATES OF DUTY

(Percent ad valorem)

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (m): Ferroaluminum vanadium, ferro- manganese vanadium, ferrosilicon vanadium, and ferrosilicon aluminum vanadium -----	25	25	25	25

### Comment

The products included in this summary--ferroaluminum vanadium, ferromanganese vanadium, ferrosilicon vanadium, and ferrosilicon aluminum vanadium--are commonly known as reaction or process alloys. They are used to produce alloy steels with different qualities than the steels produced with the more common additive ferroalloys. Although consumption per unit of finished steel is small (2 to 5 pounds per ton), these alloys have a pronounced effect on the characteristics of the final product. They are used especially in the manufacture of alloy steels with certain desired qualities of hardness.

Production is unrecorded but must be small because of the limited consumption. There are no imports or exports.

J. ALLOYS OF ONE OR MORE OF THE METALS BARIUM, BORON, CALCIUM, COLUMBIUM (OR NIOBIUM), STRONTIUM, TANTALUM, TITANIUM, URANIUM, VANADIUM, AND ZIRCONIUM WITH ONE OR MORE OF THE METALS ALUMINUM, CHROMIUM, COBALT, COPPER, MANGANESE, NICKEL, OR SILICON (EXCEPT CALCIUM SILICIDE)

(PAR. 302 (n) )

Table XVII-20. CHANGES IN UNITED STATES RATES OF DUTY

Item	Tariff rate in-			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (n): Alloys, n.s.p.f., of one or more of the metals barium, boron, calcium, columbium or niobium, strontium, tantalum, thorium, titanium, uranium, vanadium; or zirconium with one or more of the metals aluminum, chromium, cobalt, copper, manga- nese, nickel, or silicon -----	Various	25% ad val.	25% ad val.	25% ad val.

TANTALUM, THORIUM, TITANIUM, URANIUM, VANDIUM,  
AND ZIRCONIUM, WITH ONE OR MORE OF THE METALS,  
ALUMINUM, CHROMIUM, COBALT, COPPER, MAN-  
GANESE, NICKEL, OR SILICON: UNITED STATES  
IMPORTS FOR CONSUMPTION, BY PRINCIPAL  
SOURCES, IN SPECIFIED YEARS, 1937-44.

Quantity (pounds)

Country	1937	1938	1939	1940	1941	1944 /1
Norway	388,801	79,357	715,781	651,625	-----	---
United Kingdom	---	---	100	2,240	25	---
France	---	---	---	44,800	42,646	---
Canada	---	---	---	---	-----	292
All other	---	---	---	---	---	---
Total	388,801	79,357	715,881	698,665	42,671	292

/1 There were no imports in 1942, 1943, 1945, or 1946. In 1947, 9,527 pounds, valued at \$3,598, was imported--4,000 pounds, valued at \$564, from Canada and 5,527 pounds, valued at \$3,034, from the United Kingdom.

Source: Official statistics of the U.S. Department of Commerce.

Note. Statistics on production and exports are not available, but production is believed to be small and exports negligible or nil.

Comment

Most of the alloys covered by this summary are electric-furnace products used only experimentally or in small commercial quantities. They are mostly used for purifying steel, cast iron, and various non-ferrous alloys. Many are produced for highly specialized purposes, such as chromium-vanadium alloys which are used to add vanadium to high-speed tool steels where both chromium and vanadium are desired; manganese-boron alloys for the manufacture of monel metal; manganese-silicon-boron for scavenging ferrous and nonferrous alloys and increasing depth chill and shortening the heat-treating cycle in cast irons; titanium-aluminum alloys for making other alloys of aluminum; titanium-copper for age-hardening copper alloys; and the zirconium alloys for scavenging steel and nonferrous metals.

the ores from which they are derived, are important for military purposes. For example, the ores of columbium, tantalum, vanadium, and zirconium are included in the Army-Navy Munitions Board list of strategic materials being stockpiled. Both ore and metal of thorium and uranium are under control of the United States Atomic Energy Commission.

In prewar years Norway was the chief supplier of the small United States requirements of these alloys, and there was little domestic production. With the advent of war, United States producers undertook to supply home requirements. Since 1941 imports have nearly ceased and domestic output has been adequate to meet consumption needs. Although no statistics are available, it is known that production is small, owing to the nature of the demand. Exports have been negligible or nil.

#### K. SILICOSPIEGEL

(PAR. 302 (o) )

Table XVII-22. CHANGES IN UNITED STATES RATES OF DUTY

(Percent ad valorem)

Item	Tariff in			
	Act of 1922	Act of 1930	1945	1948
Par. 302 (o): All alloys used in the manufacture of iron or steel, n. s. p. f. ; Silico-spiegel-----	25	25	25	12-1/2 <u>/1</u>

/1 Geneva, 1948.

Table XVII-23. SILICOSPIEGEL: UNITED STATES IMPORTS FOR CONSUMPTION, BY PRINCIPAL SOURCES, IN SPECIFIED YEARS, 1937-47.

Year	Quantity		
	All countries	Norway	Canada
	Pounds	Pounds	Pounds
1937	695,900	557,220	138,680
1938	---	---	---
1939	---	---	---
1943	---	---	---
1946 <u>/1</u>	6,750	---	6,750
1947 <u>/1</u>	---	---	---

/1 Preliminary.

Source: Official statistics, U.S. Department of Commerce.

#### Comment

Silicospiegel is an alloy of silicon and manganese with iron and is employed in making furnace additions of silicon and manganese to open-hearth steels. Both the silicon and manganese in the alloy act as strong deoxidizing agents; in the process of steel production they aid formation of a thin, fusible slag which makes easier the production of steel with a low proportion of impurities.

There is no domestic production of silicospiegel. The alloy was imported in Norway and Canada in an attempt to produce a steel that might avoid payment of the existing duty on manganese. But the attempt proved futile. Under the Brazilian tariff, effective January 1936, the specific duty on the manganese ore and concentrates was reduced by 50 percent. As a result, it then became possible to manufacture more economical and practical alloys of manganese in the United States, and imports of silicospiegel virtually ceased. In the Geneva agreement the duty on manganese in ore and concentrates was further reduced by 50 percent.

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## CHAPTER XVIII ALLOYS AND METALS AND COMPOUNDS

### A. TRANSITION OF MANGANESE FROM ORES TO ALLOYS

The transition of the manganese from ores to alloys in end products usually involves at least one intermediate master-alloy step, particularly in the metallurgical industries, both ferrous and non-ferrous. About 95 to 96 percent of the manganese ore is used by the metals industries, the remaining ore being divided between the battery and the chemical industries in which the ore may be used directly in the process.

With the above picture in mind, it may be seen that the production of master alloys and manganese metal has primary importance on a volume basis. The nonferrous-metal industries have found it possible to adapt their processes to either the ferro-alloys or manganese metal for use in making up their respective alloys. Obviously, then, attention is focused on the production of ferro-alloys and of manganese metal.

Since iron and manganese will alloy in all proportions, it is only natural that use has been found for a group of ferro-alloys that extend through the whole iron-manganese binary alloy range. Such ferro-alloys have evolved into three main classifications: Manganese pig iron-spiegeleisen, and ferromanganese. Other ferro-alloys containing silicon in addition to the iron and manganese are classified as silicospiegel and silicomanganese. Rather than being substitutes for each other, these various grades and classifications of manganese ferro-alloys are, in general, complementary in usage but substitutable within certain limits.

Ferro-alloys are produced primarily for consumption by the steel industry and the various products may best be considered on that basis.

Ferromanganese - Manganese is generally added to steel in the form of ferromanganese. The most commonly used grade is standard or high-carbon ferro of the following typical composition. (1)

	Percent
Manganese	78 to 82
Iron	12 to 16
Carbon	6 to 8
Silicon	1.0 max.
Phosphorus	0.3 max.
Sulphur	0.05 max.

The alloy may be furnished in various crushed or ground sizes, ranging from 75-pound lump to pieces of 2-inch diameter. In all sizes grades, a minimum of fines is desirable in order that oxidation losses may be kept to a minimum when the alloy is melted. To control size, ferromanganese should resist disintegration or crumbling, a condition that may be obtained if the alloy is properly made. In general, all ferromanganese, in fact, all alloys, should be free of sand or slag, have a uniform composition, and contain a minimum of objectionable impurities.

Additions of ferromanganese to steel are made either in the furnace at the end of the steel-making process or after the metal has been tapped from the furnace into the ladle. Neither of these points in the process offers any appreciable opportunity for removing any of the carbon, silicon, phosphorus, or other elements that may be present in ferromanganese and are therefore added to the steel along with the manganese. For this reason, different grades of ferromanganese have been developed that have definite limits set on what may be considered objectionable inherent elements.

Composition of grades of ferromanganese in percent. (2)

	Mn	C	Si	Phos
Standard or high-carbon	78-82	6.75	1.0	0.3
Medium-carbon	80-85	1.5	1.5-2.5	---
Low-carbon	80-85	0.1-0.75	1.0-7.0	---
Low-phosphorus	78-82	5.5-6.5	5.0	0.1
Low-iron	85-90	7.0	3.0	---

Standard Ferromanganese - Standard (or high-carbon) ferromanganese may be considered the base alloy of which the other grades are variations. It is by far the most widely used type and usually is made up to run between 78 to 79 percent manganese, although slightly higher or lower amounts of manganese may be present without making the product unusable. The more closely the alloy can be held to a constant analysis, the easier it is for the steelmaker to use, since calculations can be standardized and error reduced to a minimum.

Low-Carbon Ferromanganese - This grade is used for adding manganese to steels with such a low carbon content that neighbor high- or medium-carbon alloy can be tolerated. The alloy is particularly useful in adding manganese to some chrome-nickel steels where the carbon content must be kept below 0.10 percent. Several grades of low-carbon ferromanganese are available in gradually increasing

carbon content as listed. (3)

Grades of low-carbon ferromanganese in percent.

	Manganese	Carbon	Silicon	Phos.
Group I	90.00	0.07 Max.	1.00 Max.	0.06 Max.
Group II	80-85	.10 Max.	1.00 Max.	.20 Max.
Group III	80-85	.15 Max.	1.00 Max.	.20 Max.
Group IV	80-85	.30 Max.	1.00 Max.	.20 Max.
Group V	80-85	.50 Max.	1.00 Max.	.20 Max.
Group VI	80-85	.75 Max.	7.00 Max.	.25 Max.

Medium-Carbon Ferromanganese - Medium-carbon ferromanganese is generally used in making ordinary low-carbon steels and may be used in Hadfield steel (Mn, 13%) under certain conditions where a high percentage of returned scrap is being used. One grade is generally available. (4)

Medium-carbon Ferromanganese, in percent

Manganese	80-85
Carbon	1.50 Max.
Silicon	1.50 Max.

Spiegeleisen - Spiegeleisen or spiegel may be considered as high-manganese pig iron and may be used in open-hearth or Bessemer practice. Spiegel is ordinarily used as a furnace addition and is therefore furnished in large chunks or pigs. Several grades are available, all of which have relatively low maximum limits for phosphorus and sulfur. The three most-important grades are listed below. (5)

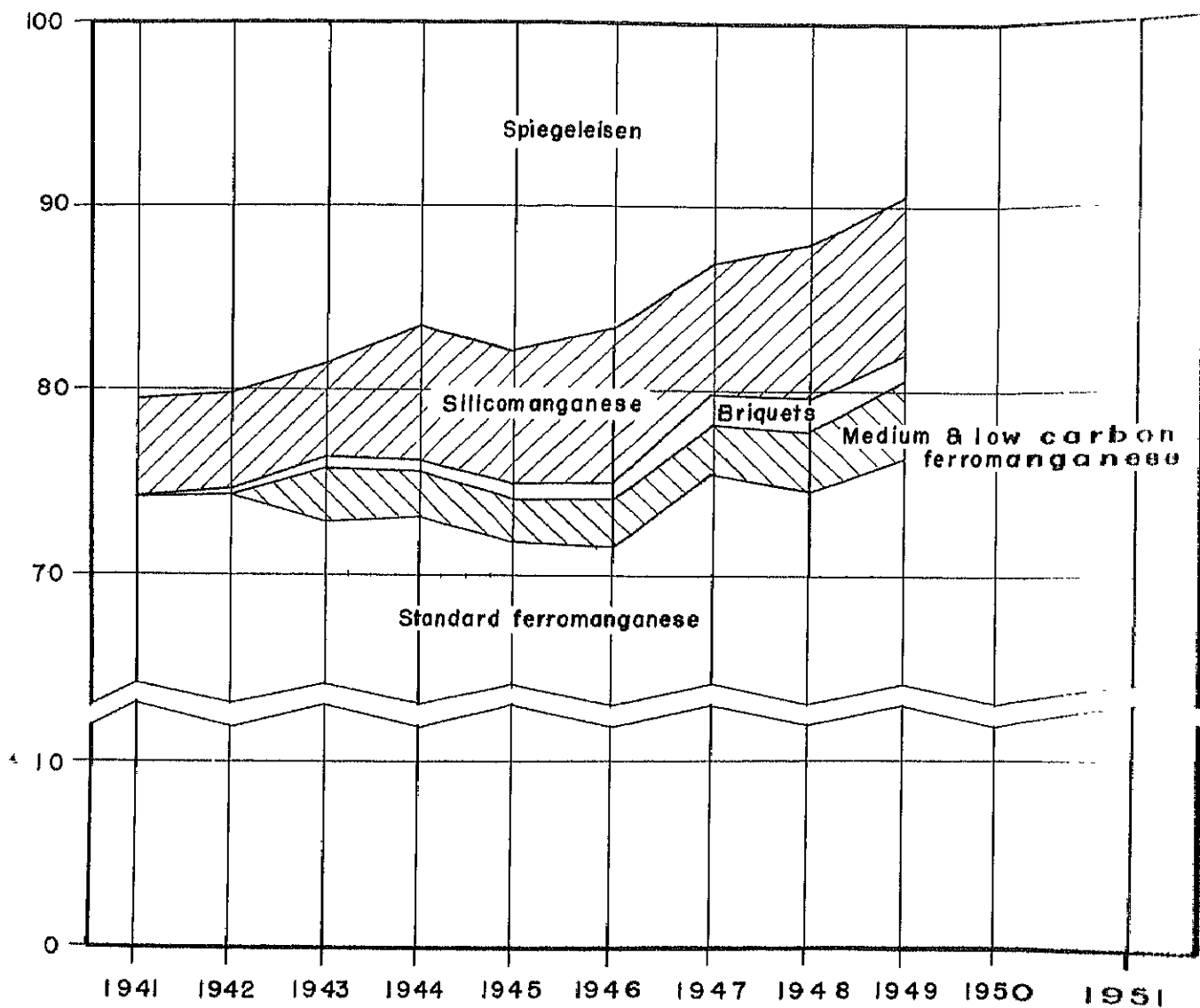
Grades of Spiegeleisen in percent

	I	II	III
Manganese	16-19	19-21	26-28
Carbon	6.50 Max.	6.50 Max.	6.50 Max.
Silicon	3.00 Max.	3.00 Max.	1.00 Max.

Silicomanganese - The low carbon:manganese ratio in this alloy makes it useful for adding manganese to low-carbon steels in which silicon may be tolerated. The presence of silicon in the alloy has the advantage of producing a somewhat cleaner steel as well as reducing the time required from the addition of alloy to the pouring of the ingot.



FIGURE XVIII-1 Consumption pattern of manganese alloys in percent of total,  
United States, 1941-1949



These effects are due to silicon being a more powerful oxidizer than manganese. Silicomanganese is produced in several grades but that most generally useful has the following analysis. (6)

	<u>Percent</u>
Manganese	17-20
Silicon	65-70
Carbon	1.50 Max.

Silicospiegel - This alloy has uses similar to ordinary spiegel-eisen and may be substituted for spiegeleisen in many cases. A typical electric-furnace product will analyze: (7)

	<u>Percent</u>
Manganese	25-28
Silicon	5-6
Carbon	4

Manganese Briquets - To meet metallurgical conditions requiring the use of small, accurate amounts of manganese, ferromanganese is ground and briquetted. Each briquet is made to contain 2 pounds of manganese and will weigh about 3 pounds in all. In this form, manganese may be added in small amounts without involving a weighing problem.

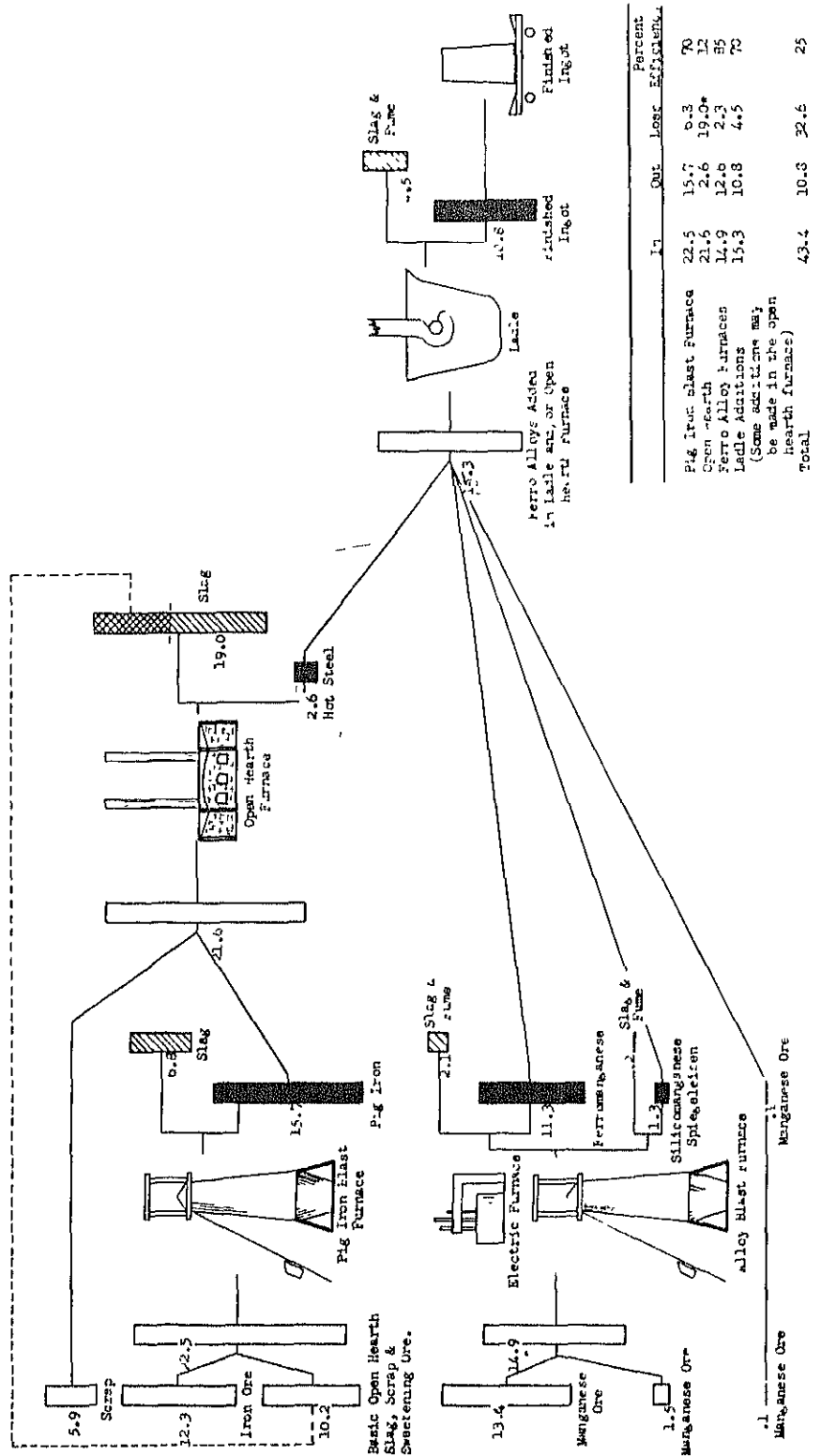
Miscellaneous Grades - Other grades of alloy than those considered above are produced including low-phosphorus ferromanganese and low-iron ferromanganese. These alloys are used in special instances in steel practice on a basis similar to other grades wherein certain elements may have set maximum limits.

Low-iron ferromanganese has a particular use in the nonferrous industries such as aluminum and brass where manganese is needed but iron is held to be an impurity.

## B. CONSUMPTION OF MANGANESE IN IRON AND STEEL

In general, the consumption of manganese is taken as the amount of manganese used as manganese ferro-alloys consumed annually by the steel industry. Although it is true that this figure, when translated into pounds of manganese used per ingot ton of steel produced, has definite value in predicting the amounts of manganese that will be consumed as alloys or as ore, complete reliance on such a picture tends to hide any of the other sources of manganese used in steel

FIGURE XVIII-2. Manganese in pounds to produce an average ingot ton (2,000 pounds) of steel showing sources, processes and losses.



\* 45 percent of basic open hearth slag is normally recirculated through the pig iron blast furnace primarily to recover the iron content.

production.

It has been estimated that, in total, about 43 pounds of manganese is introduced into the steel-making process per ton of ingots. (8) If this thought is expanded and investigated some interesting facts come to light. Using the Mining Directory of Minnesota published annually by the University of Minnesota as an indicator of the amounts of manganese in Lake Superior iron ores, information obtained by questionnaire originating with the American Iron and Steel Institute's Committee on the Conservation of Manganese, data from the 1948 Minerals Yearbook, Bureau of Mines, United States Department of the Interior, and empirical data from discussion with persons familiar with steel industry practice a rough approximation can be worked up showing the sources and flow of manganese through a typical steel making process. This has been worked out in diagrammatic form in figure XVIII-2.

Certain phases have necessarily been eliminated or condensed in the graphic presentation, and it should be remembered that the data are only correct insofar as they concern the use of what are referred to as Lake Iron Ores. Of the domestically produced iron ore from 1941 to 1949 inclusive 83.9 percent originated in the Lake Superior region. (9) Total iron-ore imports during the same period were low, averaging less than 5 million tons a year, so that the diagram may be considered as valid for at least 75 percent of United States steel production.

By reference to the diagram, it may be seen that 12.3 pounds of manganese was introduced into the process through the use of some form of manganese ore. Somewhat more than 5.9 pounds of manganese entered through scrap and about 8.5 pounds through basic open-hearth slag, making a total of 14.4 pounds of recirculating manganese. It should be noted that the recirculating manganese from slag would largely drop out if the manganese in the iron ore were eliminated and not made up from some other source.

Under present steel practice, it may be seen that the greatest point of loss in the system is in the open-hearth furnace slag, which

contains about 19 pounds of manganese per ton of steel or more than the entire amount of manganese used in the addition alloys.

As was mentioned, about 8.5 pounds of this total loss is recovered in the blast furnace, however, the remaining 10.5 pounds is discarded on the slag dump. This represents such an appreciable stock of manganese that some companies are separating this slag awaiting some process for recovering the contained manganese. (10)

One other heavy loss of manganese in the system shows up at the pig-iron blast furnace, where about 6.8 pounds is lost in the slag. Unfortunately this manganese is so diluted owing to the large volume of the slag that recovery of the metal is economically and metallurgically impractical.

Although many of the data used in arriving at the figures used in the diagram are empirical in nature, it is believed that the basic assumptions are valid and point up the workings of the system of steel-making practice as it has developed.

#### C. USE OF OTHER ALLOYS TO REPLACE STANDARD FERROMANGANESE

In November 1948, the National Security Resources Board requested the American Iron and Steel Institute to assist in problems concerning the conservation of manganese. The institute appointed a special committee, which rendered a report in June 1949.

Since this committee included representatives of almost all of the steel industry, it is assumed that their report is practical from the standpoint of the industry, and the report is included in part on the following page.

1. Downgraded Ferromanganese. Downgraded ferromanganese contains less manganese than the standard grade (78-82 per cent manganese) including those ferroalloys of approximately 50 to 78 per cent manganese.

Downgrading standard ferromanganese can be of prime importance in any program directed towards the conservation of manganese because it permits the use of large quantities of low grade ore which cannot be used to produce standard ferromanganese. As the manganese is lowered in the alloy it does not have the universal application of the standard ferromanganese. It must be kept in mind that when producing downgraded ferromanganese, less tons of manganese are produced per day per furnace than when producing standard ferromanganese. Moreover, less downgraded ferromanganese can be added to the ladle, therefore, greater quantities must be added in the furnace with resultant decrease in manganese recovery.

Some downgraded ferromanganese is now being produced in order to utilize substandard ores.

2. The Use of Spiegeleisen as a Substitute for Ferromanganese. The use of spiegel as a substitute for standard ferromanganese is well known in the art of steelmaking. Its production and utilization was carefully investigated and reported upon by the Technologic Committees on Manganese, Office of Production Management, February 21, 1941 in PM 89.

This Committee has no reason for changing the suggestions made in PM 89. The following information is adapted from that report:

Spiegel, an alloy usually containing about 20 percent manganese, is used in considerable quantities in steelmaking as a preliminary deoxidizer or as an addition intended to cleanse the metal prior to final deoxidation. In the current method of addition to the steel, the amount of manganese retained in the steel is rather small. However, spiegel can be used, as a substitute for ferromanganese, to raise the manganese content of the product with good metallurgical results, although the cost of manganese so added may well be higher than if standard ferromanganese were used.

Some domestic ores are suitable for the production of spiegel, but the cost of contained manganese will probably be higher than if imported ores were readily available for the production of standard ferromanganese. Nevertheless, domestic manganese ores are avail-

able, and the process of producing spiegel is a standard metallurgical process, requiring standard metallurgical equipment.

A careful survey of the various grades of steel produced in this country shows that from a metallurgical standpoint spiegel could, if necessary (under emergency conditions) be substituted for at least 20 per cent of the required ferromanganese. Based on the production of 90,000,000 tons of steel per year, this substitution would involve the production of about 600,000 tons of spiegel per year. If the amount of manganese in the spiegel could be raised from the present 20 per cent to 35-40 per cent, with a manganese-phosphorus ratio of at least 160 to 1, its use as a substitute would be greater, because a larger amount of manganese would be added in a given weight of spiegel, and the minimum limit of carbon content of the steel would be lowered sufficiently to include certain grades for which spiegel cannot now be used. Furthermore, this more concentrated alloy would permit of closer carbon control in the product than is possible with common spiegel, and would be more satisfactory for handling and stocking in the open hearth shops.

3. The Use of Silicomanganese as a Substitute for Ferromanganese. This group of manganese alloys containing from 65-68 per cent manganese, 15-20 per cent silicon and two per cent maximum carbon are widely used as deoxidizers and alloying agents in the production of killed and semikilled steels. They are specially suited for manganese additions to low carbon steels in which the added silicon can be utilized, because of low carbon content of the alloy.

Silicomanganese containing up to about 8 per cent silicon can be made in blast furnaces. The alloys containing over 8 per cent silicon are made exclusively in electric furnaces. High silica domestic manganese ores can be utilized in the production of silicomanganese alloys as a part of the charge.

While silicomanganese alloys can be made in various grades, the grade most widely used at the present time and the one meeting almost all requirements, contains 65-68 per cent manganese, 15-20 per cent silicon, two per cent maximum carbon and 0.25 per cent maximum phosphorus. This alloy is used both as a block in the furnace and as a ladle addition. In certain types of steel such as forging steels, high manganese steels and low carbon killed steels, silicomanganese alloys are preferred for blocking because of the savings in time from block to tap and maintenance of furnace temperature.

Production of silicomanganese in 1948 was approximately 60,000 tons. It is estimated that about 30,000 tons were used solely as a blocking agent and the balance as a ladle addition of silicon and manganese. In case of an emergency, the steel industry could substitute approximately 200,000 tons additional silicomanganese for 175,000 tons of ferromanganese and 36,000 tons of silicon in silicon ferroalloys.

4. The Use of Silicospiegel as a Substitute for Ferromanganese. The use of silicospiegel as a substitute for ferromanganese is of special importance for this ferroalloy can be used for blocking or killing of steel heats in the furnace in the place of silvery iron, 25 per cent ferrosilicon, 50 per cent ferrosilicon and silicomanganese, and at the same time be a source of considerable manganese. It is of further interest because silicospiegel can be made in either electric furnaces or blast furnaces now making silvery iron and spiegel and in electric furnaces making other silicon alloys and standard ferromanganese.

The source of manganese ore for making silicospiegel alloys can be domestic low grade ores, some of which may be amenable to preliminary beneficiation. Open hearth slags are sufficiently high in manganese to warrant investigation as a source of silicospiegel or other manganese alloys.

Silicospiegel of low silicon contents, three to six per cent, is not produced in any quantity at the present time due to the fact that there is no economic advantage to be gained over producing spiegel of 1.50 per cent silicon with current sources of low grade manganese ores. In producing three to six per cent silicospiegel in blast furnaces, furnace production is reduced while manganese recovery is about the same as in producing spiegel.

In the event that suitable raw materials become available any silicospiegel of higher manganese content than that discussed above would be more desirable to the steel industry.

Although the committee has made several important contributions to the manganese picture, they did not consider some of the limiting factors that would work against changing the product proportions of the manganese-alloy-producing industries.

1. The present production pattern of manganese bearing ferroalloys may be assumed to have an adequate supply of coke. In face



of the present generally tight coke supply, it may also be assumed that there is no surplus of coke on the market and that there is hardly any surplus of idle marginal coke-producing facility, so that no great increase of coke is probable in the near future; in fact, no increase is possible without installing new capacity.

As can be seen by reference to the 1948 figures on coke consumption, 2.78 pounds of coke per pound of manganese is required in ferromanganese and 7.00 pounds of coke per pound of manganese in spiegeleisen. In other words, it takes 2 1/2 times as much coke to get 1 pound of manganese as spiegeleisen as it does a pound of manganese as ferromanganese. Since there would be the same demand for manganese in the steel as before and since the use of spiegeleisen is a less-efficient means of adding manganese to steel, there would be a pound-per-pound increase of coke of over 150%.

From the standpoint of available ferro-alloy facilities, the same problem is presented. To get the same amount of manganese as in a ton of ferromanganese (at 80 percent Mn) industry would need 4 tons of spiegeleisen (at 20 percent Mn). The same blast furnace will not produce four times as much spiegeleisen as ferromanganese, the ratio being more like 1:2.5. Therefore, about 35 percent more blast-furnace capacity would be needed to produce the same quantity of manganese.

While it is true that the percentage ratio of the consumption of spiegeleisen and of ferromanganese indicates a considerable drop in the use of spiegel in the last few years, it is also true that the whole group of manganese ferro-alloys has increased. Any additional coke capacity released during the war and postwar era has been taken up by other facilities, mostly within the steel industry. Any attempt to push the usage ratio of ferro-alloys back to that of some arbitrary period would cause innumerable dislocations within the steel industry, the aggregate of which would tend to reduce steel-making capacity and actual steel production.

The problem of manganese-ferro-alloy production in blast furnaces is necessarily long-range. In addition, it is closely knit with steel production, not only in the sense that the demand for steel largely dictates the demand for the ferro-alloys, but that both steel and the alloys require the same equipment and the same fuels and fluxes.

## D. THE OPEN-HEARTH FURNACE

The open-hearth furnace is a rectangular brick structure erected on a concrete foundation and supported on the sides and ends by a system of steel channels and slabs, known as buck stays. Furnaces range in capacity from 15 to 300 tons with a common size about 100 ton. A 100-ton furnace is approximately 80 feet long, 20 wide, and 10 high, excluding the auxiliary heating equipment. Basic and acid furnaces have the same general construction, except for the type of brick used to line the furnace and the type of material used to make up the bottom of the furnace.

The hearth of the furnace, the portion that holds the metal during the processing period, is constructed of layers of brick covered with a coating of some refractory material. In use, the hearth becomes virtually a dish-shaped monolith, strong enough to withstand the impact of the metal when being charged as well as the floating effect of the metal on the brickwork. The backwall of the hearth is pierced by a tapping hole at a height that permits draining the molten metal from the furnace. Above the tapping hole may be located one or more slag holes, which permit removal of the molten slag which floats on top of the metal bath.

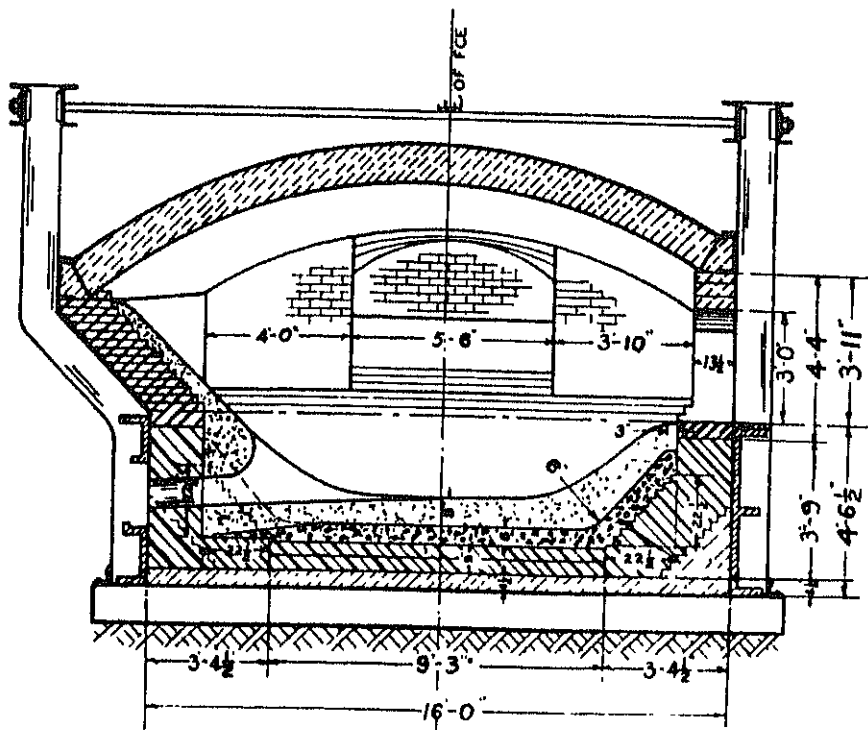
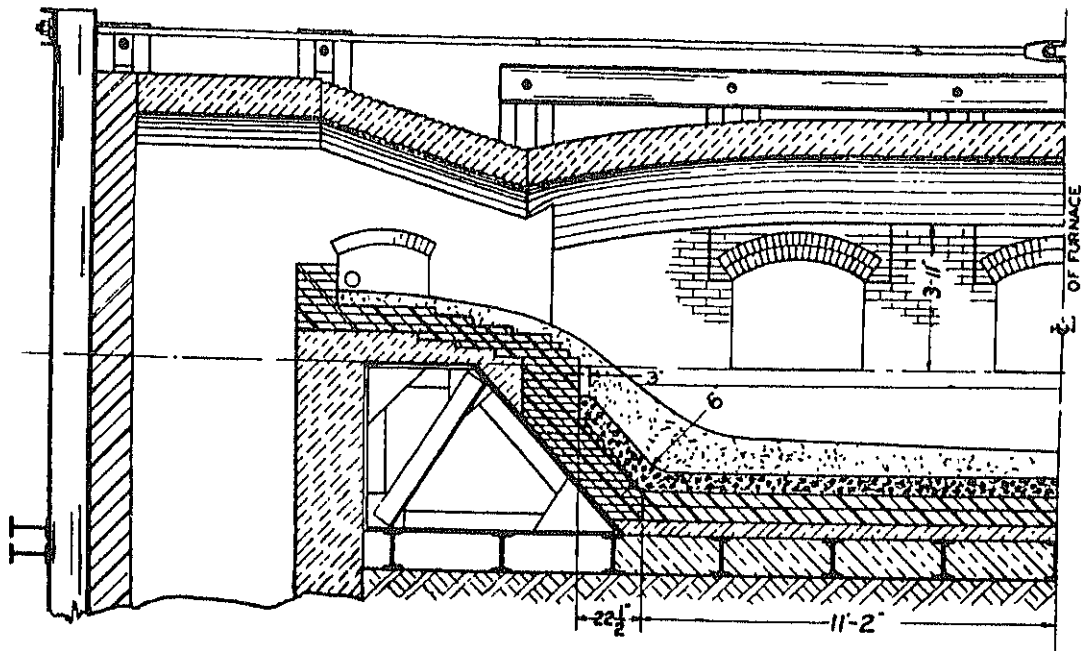
The furnace walls are built up from the lip of the hearth, the backwall being solid while the frontwall is equipped with three to five doors through which the furnace is charged and worked and through which furnace additions may be made.

The ends of the furnace are also of brickwork, known as bulkheads, and are provided with openings called ports through which gas and air are introduced over the molten-metal bath. Fuel is supplied through these bulkheads in various manners, depending on the type used - gas, liquid, or pulverized coal.

Fuel and air are introduced at one end of the furnace and burned gases exhausted at the other, the direction being reversed from time to time during furnace operation. Below the furnace is a system of regenerators or checker changers, wherein the heat of the exhaust gases is used to preheat the air and sometimes fuel before introduction into the furnace.

The roof of the furnace is usually somewhat over 1 foot in thickness and arched from front to back. Since the roof must be replaced comparatively often, it is constructed independent of the walls and

FIGURE XVIII-3. Basic open-hearth furnace



XVIII-18

ends and held at the base of the arch by the steel-furnace framework. Great care must be used during furnace operation to protect the roof from direct flame, since it is made up of silica brick which will fuse and finally melt at high temperature.

#### E. MANGANESE IN THE OPEN-HEARTH FURNACE AND LADLE

In general, additions of manganese as steel ferro-alloys in the open-hearth and in the ladle may be assumed to accomplish the same end purpose with three general exceptions: (a) A somewhat cleaner steel from the standpoint of inclusions may be had by furnace additions; (b) when large amounts of ferro-alloy must be added, the material may be better-absorbed in the furnace, since ladle additions may chill the steel too quickly; (c) ladle additions are more efficient in recovering the desired alloying element.

Some divergence of opinion seems to exist as to the relative efficiency of furnace and ladle additions. The following table sets forth one group of data. (11)

##### Recovery efficiency of furnace and ladle additions in percent

Material added	Element	Amount in %	Furnace	Ladle
Ferromanganese	Mn	0.10 - 0.20	0.50	85-90
Spiegeleisen	do.	.10 - .20	Never	80-90
do.	C	.10 and up	Never	100

Perhaps a more inclusive attitude was taken by American Iron and Steel Institute Committee on the Conservation of Manganese in the following from its report in 1949. "The efficiency of furnace additions will vary from 45 to 70 percent depending on the grade of steel being made. Ladle additions vary from 60 to 85 percent in efficiency, again depending on the grade. There are definite limits to the amounts of manganese which can be added to the ladle from a steel quality standpoint for several grades, and the balance of the manganese must be added in the furnace. The committee believes that each steel producer should carefully survey his practice with respect to ladle and furnace additions and make the maximum ladle addition consistent with the quality requirements of each product."

Manganese as a Deoxidizer - Deoxidization of steel refers to conversion of iron oxide to iron, which requires the addition of some element whose oxide is more stable than iron oxide. Although it is true that manganese oxide is more stable than iron oxide, its relative strength as a deoxidizer is low. The effect of manganese on the oxygen in steel is scarcely measurable in concentrations up to 0.35 percent, and a more powerful deoxidizer must be used, such as silicon or aluminum. It has been suggested that there is no valid reason for using manganese in steel merely as a deoxidizer.

Manganese as a Controller of Sulfur - In the absence of manganese, the sulfur present in all commercial steel to some extent combines with the iron in such a manner as to "wet" the crystals of metal and forms surrounding films. These sulfide films destroy intercrystalline cohesion at about 1,800° F. which temperature is below the normal hot working range. This condition is known as "hot shortness" and results in the effected steel opening up in cracks when being worked.

The addition of manganese results in the formation of manganese sulfide, which has a high melting point and tends to exist in small globules which are least likely to affect the intercrystalline structure. Since manganese is distributed among iron, carbide and sulfide phases in the steel, more must be used than just enough to satisfy the sulfide requirements. Efficiency must also be rated according to the amounts of oxygen in the steel. It has been estimated that silicon additions to deoxidize the bath manganese additions will increase manganese efficiency 10 percent. (12)

Manganese as an Alloy - Manganese as an alloying element produces two distinct effects. The properties of steel are largely formed by the two main constituents ferrite and iron carbide. Manganese is a strengthener of ferrite. Of greater importance it tends to make finer the pearlite structure which promotes greater strength.(13) For further information as to the alloying effect of manganese see the section entitled "Manganese Steel," p

Manganese in the Furnace or Ladle - What actually happens to the manganese in the open-hearth furnace or the ladle has been subject to much investigation. In general, the action may be simplified to a few broad statements.

A large amount of the manganese combines with oxygen to form MnO. This manganese is distributed between the metal and the slag, - 1/2 of the MnO going to the slag. The reaction may be expressed;

$\text{FeO} + \text{Mn} \rightleftharpoons \text{MnO} + \text{Fe}$  (14) and the constant for this reaction may be written  $K_{\text{Mn}} = \frac{(\text{MnO})}{(\text{Mn})(\text{FeO})}$ . The slag-metal reaction has been fairly well established by Korber and Oelsen (15) and Schenck. (16)

Probably the best summary of furnace and ladle additions is quoted. (14)

If ferromanganese is added in the ladle in making high-carbon steels, the manganese efficiency is usually about 75 percent. If the bath has not been deoxidized to some extent prior to the manganese addition the efficiency may be less and will certainly vary considerably from heat to heat. On lower carbon steels, particularly if no silicon is added in the ladle, manganese efficiencies are lower due to the higher FeO content of the steel and the ladle slag, the efficiencies averaging about 70 percent. For the best quality steel the ferromanganese should be added in the furnace, as this allows more time for the MnO formed to flux with and aid in eliminating other nonmetallic matter formed during deoxidation.

If manganese-silicon alloys are used for furnace deoxidation, a large percentage of the manganese enters the steel from the alloy and effects a saving in the amount of ferromanganese necessary to meet specifications. In this practice any ferromanganese needed is added in the furnace after the alloy and aids in fluxing out any high silica particles formed by the manganese-silicon alloy.

The deoxidation of open hearth steel is discussed from the standpoint of steel cleanliness and deoxidizer efficiency, and allied subjects, such as rephosphorization after deoxidation, are brought to the attention of the reader. Finally, a brief review of the various methods of determining inclusions is presented.

The general principle of inclusion elimination is that the particles formed on deoxidation shall be large enough, through fluxing and coalescence, that they rise out of the steel before the metal solidifies. The tendency for fluxing and coalescence is related to the fusibility of the deoxidation products, which can be predicted from the melting point diagrams of the oxides involved. The largest inclusions and those having the lowest melting points are found in the manganese silicate or manganese-aluminum silicate slags, resulting from the deoxidation of steel with manganese-silicon or manganese-silicon-aluminum alloys.

All factors considered, manganese-silicon alloys with a ratio of manganese to silicon of 4 or 5 to 1 give the best types of inclusions for rapid elimination.

The amount of deoxidizer added in the furnace is of great importance in determining steel cleanliness, as ladle deoxidizers produce inclusions, and the lower the iron oxide content of the metal entering the ladle the fewer the inclusions formed. It has been conclusively shown in this work that steel cleanliness increases with increasing additions of manganese-silicon alloys up to an addition equivalent to 0.13 percent silicon.

For certain types of materials it is necessary that some of the deoxidation products remain in the steel as a fine dispersion. Methods of obtaining such dispersions and their effect on the finished product are given in previous bulletins of this series.

The losses of deoxidizers are affected by the oxidation of the metal and slag, the physical condition of the slag, the temperature and the addition of more than one deoxidizer. The stronger the furnace deoxidation with silicon, the higher the efficiency of manganese in the furnace, and other oxidizable alloys added either in the furnace or ladle.

The comparisons between furnace and ladle additions as stated above are pointed toward the oxidation effect of manganese alloys, however, the reactions of manganese are the same no matter what the reasons for the additions.

## F. CARBON STEELS

Carbon steels contain carbon as the principal element controlling the physical properties, together with limited, and usually specified percentages of other elements, such as manganese up to 1.00 percent and silicon up to 0.2 percent, to improve the quality, as well as small proportions of residual elements, such as phosphorus and sulfur, that are not completely eliminated in the refining process.

This is the basic steel with the widest range of use throughout the industry.

Influence of Manganese - In carbon steels manganese has been used since 1856 (Mushet added it to Bessemer's steel) to overcome the deleterious effects of oxygen or FeO and sulfur or FeS. When

relatively high concentrations of these latter compounds are present they weaken the metal, particularly at hot working temperatures. Manganese added to the liquid steel reacts with both of these elements to form coalescing compounds and mixtures that separate as comparatively harmless types of inclusions. Since the reactions are between manganese and FeO and FeS, all in small amounts dissolved in a large excess of iron, a considerable excess of manganese over the theoretical amount required by these reactions must be added to obtain the desired result. This excess alloys with the iron and combines with part of the carbon to form the carbide  $Mn_3C$ , thus giving a direct effect as an alloying element. Manganese is soluble in alpha iron up to about 1.6 percent to form a single type of solid solution; from 1.6 percent to about 10.5 percent to form two types of solid solutions. Above 2.00 percent it begins to have a deleterious effect and produces embrittlement. The carbide is formed as an equilibrium or partition product in reactions involving iron, carbon, and manganese. The reasons for its usage are defined by the following statements:

1. Up to 1.00 percent manganese is used principally as a curative or corrective addition, the effect upon the properties of the steel being secondary considerations. Manganese added with other deoxidizing agents tends to prevent abnormality in steel.
2. It is added to steel in proportions between 1.00 to 2.00 percent both as a corrective and an alloying element to give steels of the pearlitic type suitable for general manufacturing and engineering purposes.
3. Its effects upon the physical properties of the steel are not, therefore, straight-line functions of the proportions added, but vary according to the amount added, the carbon content, the sulfur content, and the state of deoxidation of the steel when the manganese is added, the last in turn depending somewhat upon the method and practice followed in melting and refining. Below 0.30 percent, the deoxidizing power of manganese is slight, and the amounts partitioned to sulfur, to carbon, and to alloy are so small that their effects upon the physical properties are scarcely noticeable.

Influence of Manganese in Heat Treatment - The effect of manganese upon the heat-treating properties of the steel are not to be overlooked. Manganese markedly reduces the critical cooling rate, making the action of quenching mediums much more drastic. In the higher-manganese steels this property manifests itself in a tendency of such steels to crack just after or during the quenching. Much care,



therefore, must be exercised in selecting steel for heat treatment to secure the proper proportion of carbon and manganese, for which purpose the following statements will be found to apply in a general way:

1. Steel containing 1.00 to 2.50 percent manganese should not be quenched in water, whatever their carbon content may be, but with carbon below 1.00 percent they may, depending on the design of the part and the condition of the steel, be quenched in oil. Steels containing 0.90 to 1.00 percent carbon and about 1.80 percent manganese do not change in form or size on quenching in oil, hence are known as nonchangeable or nondeforming steels.

2. Steels containing about 1.00 percent manganese and of low or medium carbon content may be quenched in water, though the risk of cracking is still great if the carbon is above 0.50 percent and the steel is quenched to room temperature and not drawn back immediately.

3. A manganese content of 0.40 percent or less is preferable in high-carbon steels near the eutectoid (0.90% C) composition, when such steels are to be hardened by quenching in water.

4. In hypereutectoid steels, such as high-carbon tool steels, the manganese content should not exceed 0.25 percent.

5. Each 0.1 percent of manganese lowers the critical range on heating by about 3° C.

## G. MEDIUM-ALLOY STEELS

Uses and Requirements - The medium-alloy steels comprise hundreds of steels developed to meet special requirements for the construction of aircraft, automobiles, bridges, chemical engineering equipment, dams, electrical machines, food processing and preserving equipment, locomotives, machinery and machine tools, mining and milling equipment, oil winning and refining equipment, paper-making and powerhouse equipment, and many others. From this list of applications, it is evident that the requirements that must be met by the medium-alloy steels include not only high resistance to static stresses but also to dynamic stresses, besides many special requirements, such as easy hot-and cold-forming properties, good machining characteristics, high resistance to creep at elevated temperatures and to shock at low temperatures, and resistance to various types of corrosion and to abrasion and wear. Again, for some purposes the steels are used in the "as-rolled" or "as-forged" condition, but more often they

Table XVIII - I. MEDIUM-ALLOY STEELS CONTAINING MORE THAN ONE ALLOYING ELEMENT

Type	Composition, aimed for, percent of										Uses
	C	Mn	P, max.	S, max.	Si	Ni	Cr	Mo	V, min.	W	
Si-Mn SAE 9255-9260	0.60	0.75	0.04	0.05	2.00	....	....	....	....	....	Springs.
Si-Mo <u>12</u>	.15	.30	.04	.045	1.40	....	....	0.50	....	....	High Temp. tubes.
Si-V	.75	.55	.045	.045	.65	....	....	....	.15	....	Springs.
Mn-N	.30	1.00	.04	.05	.10	1.00	....	....	....	....	Cast shoes, gears, etc.
Do.	.30	1.50	.04	.05	.10	1.35	....	....	....	....	R.R. frt. car castings.
Mn-Cr-Mo	.50	1.10	.04	.05	.20	....	.60	.15	....	....	Chisels, punches.
Do.	.30	1.02	.04	.05	.20	....	.80	.30	....	....	Machinery.
Mn-Cr-V	.15 .50	1.30	.04	.04	.20	....	.45	....	.10	....	Quench and temper replaced
Mn-Mo	.20	1.50	.04	.05	.15	....	....	.30	....	....	by normalizing,
Fe.	.32	1.40	.04	.05	.21	....	....	.21	....	....	High fatigue & impact.
Do.	.47	1.34	.04	.05	.30	....	....	.30	....	....	Couplings, tires, etc.
Mn-V	.25	1.60	.045	.05	.20	....	....	....	.15	....	Locomotive tires.
Mn-Mo-V	.25	1.50	.04	.05	.25	....	....	.25	.15	....	Forged axles.
Cr-V	.30	1.10	.04	.04	.20	....	1.10	....	.15	....	Large forgings.
Do.	.50	.80	.04	.04	.20	....	1.10	....	.15	....	Do.
Cr-Mo-V	.39	.60	.04	.04	.19	....	1.40	.35	.21	....	Large springs.
Ni-Mo	.30	.65	.04	.04	.10	1.80	....	.25	....	....	Large forgings, etc.
Do.	.31	.60	.04	.04	.10	2.40	....	.45	....	....	Axles, drive-shafts, etc.
Fe.	.23	.50	.04	.04	.18	3.50	....	.51	....	....	Connect. rods, shafts, etc.
Do.	.19	.61	.03	.05	.05	3.20	....	.48	....	....	Carburized parts.
Do.	.16	.45	.10	.05	.20	3.75	....	.30	....	....	Sucker rods.
Do.	.30	.30	.04	.04	.12	4.25	....	.60	....	....	.....
Ni-Mo-V	.08	.30	.04	.04	.15	3.50	....	.51	.15	....	Light armor plate.
Ni-Cr-Mo	.32	.45	.05	.05	.10	3.50	.80	.30	....	....	Low-temp. serv.
Ni-Cr-V	.32	.45	.05	.05	.10	3.50	.80	....	.25	....	Aircraft, B.S.A. 3S11.
Ni-Cr-W	.32	.45	.05	.05	.10	3.50	.80	....	....	1.00	Do.
									....		Do.

CONTAINING MORE THAN ONE ALLOYING ELEMENT (CONT'D)

, aimed for, percent of						Uses
Si	Ni	Cr	Mo	V, min.	W	
0.40	4.00	1.25	0.25	....	....	Aircraft, B.S.A. 3S11.
.25	1.75	.65	.45	0.15	....	Large forgings.
.50 /1	....	5.00	....	....	....	Seamless alloy steel.
.50 /1	....	5.00	.45/ .65	....	....	Still tubes.
.50	....	5.00	....	....	.75	A.S.T.M.
.10	.50	.50	....	.12	1.00	Specs.
.10	4.00	2.00	....	....	....	Carburizing.
						Formerly used for armor plate.
.15	3.50	1.50	....	....	....	Do.

are subjected to hot-or cold-forming operations followed by heat treatment to develop the precise properties desired. Steels that respond best to heat treatment - that is, steels that give the widest range of properties after heat treatment or a combination of cold working and heat treatment - are those that give a pearlitic structure after normalizing. Incidentally, they must have a certain uniformity with respect to both composition and grain-growth characteristics and be relatively clean and free of inclusions --characteristics largely imparted through complete control of manufacturing conditions.

Alloying Elements - Many medium-alloy steels are covered by standard specifications of the American Society for Testing Materials and various government agencies. Among the steels developed to resist dynamic stresses and for heat treatment, the S.A.E. (Society of Automotive Engineers) steels given in chapter III, section I, represent the largest and best-known group. Added to these, however, are many others developed by the manufactures of steel, ferro-alloys, and other metals. A survey of these fields shows that the chief alloying elements employed in the medium-alloy steels are nickel, chromium, manganese, molybdenum, vanadium, tungsten, silicon, and copper. In addition to these, other elements, such as aluminum and titanium, may be employed in the manufacturing processes to control deoxidation conditions and certain characteristics, such as grain size, although only small proportions of these elements remain in the steel. Although some of these elements, particularly nickel, chromium, and molybdenum, are used singly, most of them are employed in conjunction with others and in various combinations. In these combinations, the properties imparted to the steel differ greatly from those imparted by one element alone, because each of them alloys with iron and reacts with carbon in a different way.

The table below will help to indicate the numerous combinations of alloying elements that may be used along with the application of the type steel produced and is by no means complete.

## H. HIGH-ALLOY STEELS

Research and development in the field of high-alloy steels are always underway. Better steels for old uses and new steels for new uses are being advanced. Many of these special steels are made under patents and licensing systems and are marketed under special trade names.

In general, it may be said that the proportion of manganese

used in these steels is low, running up to 0.50 percent, with relatively few exceptions. In some of the types of high-alloy steels that have a higher proportion of manganese, changes are underway that may tend to increase or decrease the amounts of manganese consumed,

One way in which the production of high-alloy steels may influence the manganese picture is through possible dislocation of part of the electric-furnace ferro-alloy capacity. A sudden increase in the production of high-alloy steels would create a bigger demand for the less common ferro-alloys, and conceivably the ferro-alloy industry would be forced to divert furnaces or electric power or both from the production of high-low-and medium-carbon ferromanganese to the production of other ferro-alloys, thus forcing some dislocation in the supply of manganese ferro-alloys.

Two types of high-alloy steels using a somewhat higher proportion of manganese are mentioned to show the role that manganese may play in the high-alloy steels.

Oil-hardening manganese steels are used for master tools and gages, special taps and broaches, and, particularly, for dies that cannot be ground after hardening or that are of a design likely to cause them to crack in water quenching. They also are applied to many other uses. In general, these steels are intended for articles that must be made with exactness as to form and dimensions and must be hardened after machining. They have been referred to as nondeforming or nonshrinking steels, because they are designed to show little change in volume from the annealed state after being quenched and tempered at 400° F. The original type contained about 0.90 percent carbon and 1.60 percent manganese but was improved, for some purposes, by addition of vanadium to impart resistance to grain growth. Manganese lowers the critical range, and small sections of this steel can be hardened by quenching at temperatures just below 1,400° F. In later types some of the manganese was added to increase the hardness and impart resistance to grain growth. The commoner types are represented in the table on the following page.

(Table XVIII-2.)

The surface hardness obtained on quenching any of these steels depends upon the size of the section, the quenching oil used, and the manner of quenching. Additional hardness may be had by quenching the last three types from temperatures on the high side of the range. The hardness after tempering at 400° F., the usual temperature, will be within the range 59 to 65 Rockwell C. Tempering within the

Table XVIII-2 OIL-HARDENING MANGANESE STEELS

Type	Composition, percent										Quenching Temperature, °F.	Annealing Temperature, °F.
	C	Mn	P, max.	S, max.	Si	Cr	Mo	W	V			
1. 0.90% C-1.60% Mn	0.85/0.95	1.50/1.75	0.025	0.025	0.20/0.40	.....	.....	.....	.....	.....	1,385-1,410	1,375-1,400
2. C-Mn-V	.85/ .95	1.50/1.75	.025	.025	.20/ .40	.....	.....	.....	0.10/0.25	.....	1,400-1,425	1,375-1,400
3. C-Mn-Cr	.90/1.00	.90/1.25	.025	.025	.20/ .40	0.50/0.90	.....	.....	.....	.....	1,410-1,435	1,400-1,425
4. Mn-Cr-W-V	.85/1.00	1.15/1.45	.025	.025	.20/ .40	.30/ .60	.....	0.30/0.60	.10/ .25	.....	1,425-1,450	1,400-1,425
5. Mn-Mo-V	.85/1.00	1.35/1.65	.025	.025	.20/ .40	.....	0.20/0.35	.....	.10/ .25	.....	1,400-1,500	1,375-1,400

range 400° to 600° F. is to be avoided. Individual characteristics of the steels are: Type 1 (C-Mn) has a high harden-ability but is susceptible to grain growth and is most likely to crack. The addition of vanadium, as in type 2, tends to overcome these tendencies of the higher-manganese type. Type 3 will not harden to the same extent as types 1 and 2, because the manganese is low, and its hardening influence is not wholly compensated for by the chromium, but it is less liable to crack than any of the other types. Type 4 represents another attempt to overcome the brittleness of type 1 at the sacrifice of some hardness and is well-adapted to use for smaller articles. Type 5 can be made very hard and is adapted for use in large sections that require deep hardening. Both molybdenum and vanadium restrain grain growth, and molybdenum increases the harden-ability.

The silicon punch and chisel steels all contain manganese as a hardening element and are often referred to as silicon-manganese steels, though the manganese is always under 1 percent and chromium, molybdenum, and vanadium may be added to refine the grain and increase the hardenability. The silicon-manganese steels are made in two grades, a 0.55-percent carbon grade and a 0.70 percent grade, so that, based upon composition, there are in all five types, as shown in the table below. They are used principally for punches, chisels, shear blades, and springs.

Table XVIII-3, COMPOSITION OF SILICON PUNCH AND CHISEL STEELS

Composition, range in percent of	Low C, Si, Mn.	High C, Si, Mn.	Si, Mn, Cr, V.	Si, Mn, Mn.	Si, Mn, Cr, Mo.
C	0.50/0.60	0.60/0.75	0.50/0.60	0.50/0.60	0.50/0.60
Mn	.70/ .90	.70/ .90	.70/ .90	.70/ .90	.35/ .60
P (max.)	.03	.02	.03	.03	.03
S (max.)	.03	.03	.03	.03	.03
Si	1.70/2.25	1.70/2.25	1.70/2.25	1.70/2.25	.75/1.25
Cr	.....	.....	.20/ .40	.....	.20/ .40
Mo	.....	.....	.....	.40/ .60	.40/ .60
V	.....	.....	.15/ .30	.....	.....

In this table, the steels are listed in the order of their harden-ability, from the lowest to the highest. Chromium and vanadium are added to the third to overcome the tendency toward grain growth and carbide-precipitation rejection, and in the fourth molybdenum serves a same purpose. In the fifth, both the silicon and the manganese been lowered and chromium and molybdenum added, with the

effect that this steel has a greater resistance to wear than the steels containing about 2.00 percent silicon. The latter, in use as punches and shear blades, have a service life about three times greater than that of the carbon steels.

In treating these steels, it should be kept in mind that the grain of all coarsens rapidly at 1,700° F. and starts to coarsen at 1,600° F. The steels usually are quenched in water to a Rockwell C hardness of about 65 but can be quenched in oil to a Rockwell C hardness of about 60. The steel containing chromium and molybdenum hardens in air to a Rockwell C of about 56, as compared to a Rockwell C hardness of about 33 for the other steels cooled in air. In heating, all of these steels decarburize to give a soft skin, unless special precautions are taken to avoid it, or the tool is ground after hardening. Directions for proper treatment of this group are: Anneal at 1,475° F., water-quench from 1,575° F., and oil-quench those containing molybdenum from 1,650° F. Temper below 450° F., as all start to soften rapidly above 600° F., and only those containing molybdenum show any resistance to tempering.

In addition to these two examples, the manganese-steel group is discussed under "Manganese Steel."

## I. MANGANESE STEEL

The generally accepted meaning of the term manganese steel refers to the alloys of iron, manganese, and carbon containing 10 to 14 percent manganese and 1 to 1.4 percent carbon, although patents were granted to R. A. Hadfield between 1882 to 1888 that covered steels ranging from 7 to 30 percent manganese. These steels were first produced in the United States in 1892 and sometimes are referred to as Hadfield Steels.

Composition - The usual analysis of manganese steel lies between the following limits: Carbon, 1.0 to 1.4 percent; manganese, 10 to 14 percent; silicon, 0.3 to 1.0 percent; phosphorus, 0.04 to 0.10 percent; sulfur, 0.01 to 0.03 percent. The best results seem to be obtained when the carbon:manganese ratio is held to 1:10 limits, while the best range of manganese seems to be 12.5 to 13.5 percent.

Raw Properties - In the raw state, before heat treatment, manganese steel is very similar to other raw high-carbon steels, being very hard but negligibly ductile. In this raw state, the steel tends to be brittle and cannot be used successfully owing to a relatively low failure point.



Heat Treating - Heat treatment is necessary to obtain the best qualities of toughness and ductility. In heat treating, the piece is brought to a temperature of  $1,050^{\circ}\text{C}$ . and quickly quenched in water. Since manganese steel is a poor conductor of heat, a limit is imposed upon the thickness of the piece being treated. If the thickness of the metal exceeds about 4 inches, the tendency is for the outer surface to benefit from the heat treatment while the inner portions remain brittle owing to the slower cooling caused by the relatively slow heat diffusion. In the austenitic stage, the carbides are absorbed to form a homogeneous solid solution. Since the austenite phase is relatively ductile, it is desirable to retain this form, which can only be accomplished by sudden cooling. Slow cooling permits a carbide precipitation, which has the effect of robbing the metal of manganese. Unfortunately the steel cannot often be quenched from the casting heat, because the various parts are at different temperatures; those portions exposed first from the mold or those of thinner section are cooler than the remainder of the mass. Because of a high coefficient of expansion the piece tends to rupture unless uniformly heated and cooled. The addition of 3.0 to 5.0 percent nickel permits a somewhat slower cooling rate by maintaining the austenitic phase of the steel. Manganese steel tends to oxidize rapidly at higher temperatures, which necessitates quenching of the metal as soon as possible after it reaches treating temperature.

Properties After Heat Treating - The hardness of heat-treated manganese steel is of a unique quality, being tough rather than flinty. It can be easily dented with a hammer or marked with a file or a chisel. On the other hand, cutting or machining is almost impractical. Along with this peculiar type of hardness is the high ductility imparted to the steel by heat treating. The combination of these two factors, hardness and ductility, gives manganese steel high abrasion resistance and high resistance to breakage.

Contrary to most simple and alloy steels, manganese steel is strengthened by cold working. In a pull test the metal elongates in one portion, which portion then increases in strength so that further elongation takes place at some other section of the piece. If pulling is continued, all parts of the pulled section tend to stretch one after the other so that the piece finally ruptures after the stretch has been fairly uniform.

The elastic limit of manganese steel is low and not well-defined. Low-manganese steels (7 to 8 percent manganese) have a higher and better defined elastic limit. Because of its low elastic limit and high

ductility, manganese steel tends to flow under repeated blows and high compression.

Table XVIII-4. PHYSICAL PROPERTIES OF HEAT-TREATED MANGANESE-STEEL CASTINGS (17)

Tensile strength, p.s.i.	120,000 to 135,000
Yield point, p.s.i.	30,000 to 40,000
Elongation, % in 2 inches	45 to 55
Elongation, % in 8 inches	40 to 50
Reduction of area, %	35 to 45
Brinell hardness	180 to 200
Weight per cubic inch, lb.	0.286
Specific heat, 60° to 100°F.	0.145
Electrical resistance	20 to 30 times that of copper
Thermal conductivity	About 3.4 % that of copper
Resistance to abrasion by wet sand	About the same as low metalloid steel. 10 to 100 times greater after cold working.
Magnetism	Almost nonmagnetic

Manganese-Steel Castings - Manganese steel is generally cast in a similar fashion to other steel castings, except that massive designs must be supplied with large sink heads to care for shrinkage and settling of the cast metal on cooling. It is not unusual to employ iron or soft-steel cores in some large castings to overcome some of the sinkhole difficulties.

Uses of Manganese Steel - Abrasion resistance under relatively low speeds of impact makes manganese steel fitted for use in jaw, roll, or gyratory crushers or for slow-speed industrial wheels, as on mine cars. High-speed crushers or high-speed rolling-stock wheels do not give a comparably fine record of service.

Manganese steel is used extensively for cast frogs, switches, curved rails and other special applications, in railway-track work.

The toughness of the alloy makes it ideal material for safes and vaults.

Caterpillar-track equipment, such as earth-moving machines, military tanks etc., employs manganese steel in the tread plates, drive wheels, and bogey or idler wheels. Commercial applications have been devised whereby, in the interests of economy, worn drive and bogey wheels have been reused by cutting the worn rim from the relatively little worn hub and spokes and replacing the rim with a new special casting. By using this method, hubs and spokes have been "retreaded" several times, resulting in an over-all saving of a large share of the original manganese steel.

Special applications, such as cover plates for magnets where impact strength is needed, have found that manganese steels are highly suitable; although nonmagnetic itself, manganese offers no obstruction to the passage of magnetic attraction.

Hot-worked manganese steel is ordinarily employed in the form of plates, although forged castings are also used. Plates for chute linings and perforated screens or those woven from small bars have found extensive use because they resist abrasion. Forged castings are employed for dredge pins, spring hangers, etc., while other forms are used for agricultural and earth-moving equipment, especially at wear points such as bucket teeth. The use of manganese steel in the form of wire is limited, since its hardness makes the cost of drawing prohibitive in most instances.

Undesirable Qualities - The manufacturing process that may be applied to manganese steel sometimes requires a certain amount of reheating. Any such reheating, whether accidental or intended, must be held to very low limits; otherwise, embrittlement will occur. Embrittlement of heat-treated manganese steel is a function of temperature and time. A temperature of  $260^{\circ}$  C. held for only a few minutes will not cause appreciable damage; the same temperature held for 48 hours may show the beginnings of serious harm. Even a few minutes at  $540^{\circ}$  C. may result in considerable damage. Generally such damage as may be due to overheating cannot be repaired without repeating the original full cycle of heat treatment. Manganese steel is, therefore, limited in application to those uses that are within a relatively low temperature range. Although high temperatures materially damage the steel, low temperatures do not, most of the toughness being retained at temperatures as low as  $73^{\circ}$  C. The high temperature intolerance of manganese steel poses a problem in weldability that has been overcome to a large extent by adding 3.0 to 5.0 percent of nickel, which permits slower cooling rates.

The high coefficient of expansion (0.000024 inch per degree centigrade), amounting to 5/16 inch per foot of casting shrinkage, necessitates special casting techniques and special rolls for working manganese steels. Problems of distortion of parts after heat treating arise owing to the unusual amount of warping of the sections. Such distortions cannot be removed by subsequent heat treatment and must be handled mechanically. Fortunately, the inherent toughness of manganese steel makes mechanical straightening possible without damage to the metal.

## J. CAST IRON

Cast irons are alloys of iron, carbon, and silicon with other elements and run through the terms pig iron, gray iron, alloy iron, white cast iron and malleable iron; the last is discussed under a separate heading.

The uses of cast irons are quite varied, the more important being:

- Automotive cylinders
- Automotive pistons
- Brake drums
- Cams
- Machinery iron
- Water pipe
- Plowshares
- Car wheels
- Gas cylinders
- Forging dies
- Valves.

Manganese may be present in the carbide phase in gray iron or may occur as manganese sulfide in small, slate-colored inclusions throughout the metal. In ordinary commercial ranges, manganese has little effect on the mechanical properties of gray iron. About 0.30 percent more manganese than is required theoretically for combination with sulfur (which is 55/32 times the sulfur percentage) is necessary for mitigating the effects of sulfur. Most American irons contain 0.06 to 0.12 percent sulfur; hence the usual range of 0.50 to 0.80 percent manganese is sufficient.

Sulfur occurs largely as manganese sulfide and rarely as iron sulfide. Under proper operating conditions, sulfur does not seem

to exert harmful effects on gray iron in amounts up to 0.16 or 0.18 percent, provided manganese is present in amounts sufficient to prevent chill. In the absence of enough manganese, sulfur has a marked stabilizing action on the cementite and promotes chill.

## K. MALLEABLE IRON

Malleable iron is extensively used in cast machinery parts where high strength is needed. A partial list of uses shows the widespread application of this metal to industry.

- Agricultural Implements
- Automobiles
- Boilers and tanks
- Engines
- Building hardware
- Conveyor and elevator equipment
- Electrical equipment
- Hand tools
- Household appliances
- Marine equipment
- Highway equipment
- Plumbing supplies
- Railroads
- Gun parts
- Machine tools

Where batch-type reverberatory furnaces are used, the charge consists of pig iron, steel, malleable scrap, and "sprue," that is, gates, runners, and defectives from previous melts. The ingredients are so proportioned that, when the metal is melted and heated to pouring temperature, it contains, as nearly as possible, the desired percentage of carbon and contains nearly the percentage of silicon and manganese required in the finished product, but not more. For the content of silicon and manganese, ferro-alloys are used for making final adjustments after chemical analysis of the metal.

It is impracticable to produce, from a cupola, metal hot enough to pour castings and as low in carbon as is generally desired. It is therefore common to operate an air furnace with the cupola in a duplex operation. Using charges of pig iron, steel, and sprue, the cupola is operated to produce metal of about 2.75 to 3.00 percent C. The flame conditions and the length of time when the metal is in the air furnace are so arranged as to produce the desired carbon content

while the metal is being heated to the temperature needed. Silicon and manganese are added at intervals to make whatever small adjustments are required.

Composition of Malleable Iron - The molten metal must have such a composition that, when cast at the desired temperature into castings of the required size, it will be free from graphitic carbon so that flakes will not be present. The metal must also be capable of relatively easy graphitization to convert it into malleable iron. For various purposes the carbon may range from 2 to 3 percent and the silicon from 1.50 to 0.80 percent. By using graphite-free melting stock, high melting temperatures, and quick freezing, it is possible to increase the silicon in low-carbon iron to as much as 1.50 or 1.60 percent, or even higher, producing an easily graphitizable iron at some risk of forming primary graphite in large castings or with cold pouring. The manganese is generally held at 1.7 times the sulfur, plus an excess of 0.10 to 0.15 percent. As long as this ratio is maintained, the sulfur may be as high as 0.16 or 0.17 percent without detriment. In much of the metal produced by duplexing, the sulfur content is as high as 0.20 percent without causing trouble. The phosphorus content may be 0.20 percent or less. If the percentage of phosphorus is too high, especially in relation to the silicon, the iron will be subject to intergranular embrittlement when cooled quickly from the "blue-heat" range near 900° F. The difficulty can be overcome by quenching from 1,200° F in water.

## L. STEEL CASTINGS

Cast steel is steel that is poured into metal or refractory molds and allowed to solidify. This steel may be used commercially in the cast form (steel castings) or it may be processed further by hot or cold working to become wrought steel. A steel casting is a steel object that has been cast initially into the shape desired for the finished product and does not require mechanical working. The many types of steels produced as wrought steel can all be made as steel castings.

Classes - There are five classes of commercial steel castings:

1. Low-carbon steels (carbon content less than 0.20 percent).
2. Medium-carbon steels (0.20 to 0.50 percent C).
3. Higher-carbon steels (carbon content above 0.50 percent).
4. Low-alloy steels (total alloy content less than 8 percent).
5. High-alloy steels (total alloy content more than 8 percent).

Carbon-Steel Castings - Carbon-steel castings contain less than 1.70 percent C, along with other elements normally present.

These elements vary somewhat but usually are present in amounts ranging as follows: 0.50 to 1.00 percent manganese, 0.20 to 0.70 Percent Si, 0.05 percent P max. and 0.06 percent S max. In addition, Carbon-steel castings contain small percentages of other elements, which are not added but are residual in the scrap steel that constitutes a portion of the melting charge.

The medium-carbon class, comprising the bulk of the steel Casting output, is the regular-grade product. Low-carbon and high-carbon grades have been developed for steel castings so that useful Properties imparted by high and low carbon contents may be available for specialized products and uses.

Alloy-Steel Castings - A steel casting is considered to be an alloy-steel casting if the alloying elements, either residual or added, are present in quantities greater than those listed as follows: 1.00 percent manganese, 0.70 percent silicon, 0.50 percent nickel, 0.50 percent copper, 0.25 percent chromium, 0.10 percent molybdenum, 0.05 percent vanadium, 0.05 percent tungsten, 0.05 percent aluminum, and 0.05 percent titanium. Limitations of phosphorus and sulfur contents apply to cast alloy steels as they do to cast carbon steels, unless they are specified for the purpose of producing an alloy effect.

The low-alloy casting class represents a sizable portion of the total steel casting production.

Distribution of product - The normal distribution of steel castings by minor classification is as follows:

<u>Application</u>	<u>Percent</u>
Railroad and transportation castings	35
Machinery castings	25
Rolling mill castings	15
Material handling equipment	8
Valves and pressure fittings	7
Road and building construction	5
Miscellaneous	5

In a normal year the steel-casting industry ships approximately a million tons of castings. In 1943, the peak year for war production, the shipments were 2,700,000 net tons of steel castings.

Carbon-Steel Castings - Carbon-steel castings contain less than 1.70 percent C, along with other elements normally present.

are being made in every conceivable size and shape; some have sections 2 feet thick while other measure less than 1/4 inch.

#### M. HIGH-STRENGTH, LOW-ALLOY STRUCTURAL STEELS

It is not feasible to quench and temper some large steel structures, for example, bridges, railroad cars, and ships. Moreover, steels that harden during quenching present difficulties in welding. The use of ordinary structural steel for making large structures that cannot be heat-treated and for welding requires that design be based on the low yield strength of the steel (25,000 to 30,000 p.s.i.) and on the endurance limit, which for unnotched specimens approaches the yield strength.

There is an obvious need for steels that are stronger in the as-welded or normalized condition so as to allow the saving of weight. Stronger structural steels were at first provided by increasing the percentage of one or more of the three cheap elements--carbon, manganese, and silicon. Such steels were used in riveted structures. The cold formability of these strengthened steels was decreased, and their hardenability made them poorly adapted for welding.

To secure freedom from weld hardening and a better compromise between yield strength and cold formability, it was necessary to decrease the carbon content and to add alloying elements. In the presence of effective amounts of alloying elements, the practical limits of carbon content for normalizing, without production of martensite or bainite, are 0.07 to 0.17 percent; the usual range is 0.10 to 0.15 percent. Alloying elements are selected according to the need for making the austenite moderately sluggish during cooling, so that the pearlite transformation, during air cooling, will occur at as low a temperature as possible to secure fine pearlite instead of coarse. Yet the steel must not be so sluggish that any austenite is retained to form bainite or martensite at still lower temperatures.

The cementite in the finely distributed pearlite is undoubtedly the major source of strength, since carbon-free ferrite would need to be very highly alloyed if the desired strengths were to be obtained, but the strengthening of the ferrite matrix is an indispensable adjunct. At this low carbon level, carbide-forming elements, such as manganese, chromium, and molybdenum, are distributed between the cementite and the ferrite; a considerable proportion of these elements is dissolved in ferrite and strengthens it. Hence these may be used as well as the elements that do not replace iron in cementite in steel.



Silicon, copper, nickel and phosphorus are effective in that they strengthen ferrite.

The potency of the elements is in approximately the following order, and the percentages employed are about as shown here:

Carbon .....	0.10 to 0.13
Phosphorus .....	0.03 to 0.12
Molybdenum .....	0.10 to 0.25 (when used)
Manganese .....	0.20 to 1.20
Silicon .....	0.05 to 0.75
Copper .....	0.10 to 0.90
Chromium .....	0 to 0.85
Nickel .....	0 to 1.80

Phosphorus, commonly 0.10 percent, is used in the compositions that have accounted for the largest tonnages of these "mild alloy" steels made in the United States. In such an amount phosphorus strengthens steels of this carbon content, without producing the cold brittleness that has barred high phosphorus content in steels of higher carbon content. Because phosphorus may cause a banded structure, with streaks of high phosphorus concentration, when the steel is cast into large ingots, 0.25 percent carbon + phosphorus is the maximum used. Molybdenum, unusually effective as a strengthener, is recovered quantitatively from remelted scrap; and all that is added to the charge, whether as ferro-alloy or as oxide, is recovered without loss by oxidation.

Manganese may either be kept at the lowest content that will give clean steel or, more commonly, may be raised well above that content. With most furnace practice there is some uncertainty as to the percentage recovery of manganese; and, when large amounts are added in the cheapest form (high-carbon ferro-alloy), the carbon content of the melt must have been decreased correspondingly. A point of carbon is an important matter in these steels. When more than 1 percent manganese is employed, few other strengthening elements are added and these other additions are made for control of grain size. About 0.10 percent vanadium accompanied the high manganese content for this purpose in some of the earlier steels.

Chromium has effects similar to those of manganese in these steels. Chromium is cheaper as high-carbon than as low-carbon ferrochromium. One steel, containing about 0.85 percent chromium, together with 0.40 percent copper and about 0.11 percent phosphorus for resistance to atmospheric corrosion, has been found to produce

a particularly adherent type of rust. The chromium content of up to 0.50 percent, used in some other steels for the strengthening effect, confers no notable corrosion resistance by itself.

Development of these mild alloy steels so that the static strength and the endurance limit of standard structural steel are doubled, without loss of weldability or much difference in ability to be cold-formed, has been no small accomplishment. The virtues of these steels deserve to be brought more forcefully to the attention of the designer. The saving in weight through the use of these steels justifies the additional cost in many applications. Lighter weight is an advantage in the completed structure, and also reduces the cost of transporting the steel. (18)

#### N. MANGANESE IN THE BATTERY INDUSTRY

General - In the modern dry cell the negative pole consists of a zinc can that also serves as a container. The can is formed from sheets about 0.016 inch to 0.019 inch thick, generally of Prime Western spelter, substantially pure. Comparatively little of the zinc is consumed in the service life of the cell; however, the tendency is for the can to corrode unevenly in spots or streaks, thus making the problem of uniform corrosion of prime importance.

Lining the inside of the can is a special paper porous enough to permit easy diffusion of the electrolyte but firm enough to prevent the passage of fine particles of carbon and manganese ore. This paper should be capable of absorbing several times its own weight of water.

The depolarizing mix consists of calcined petroleum coke, graphite, and manganese dioxide ore. This mix, along with the carbon electrode, forms the positive pole. The mix is also impregnated with ammonium chloride and zinc chloride; these salts should be chemically pure, free from alkalies, sulfates, and other metals. The mix is wet, so that both salts are in solution throughout the interior of the cell.

The can is filled with the mix, which is tamped to within about 1/6th of the top of the cell, this space being filled with sand or some other inert material to provide a space for expansion and for the gases which may be evolved when the cell is in operation. Finally the cell is sealed at the top with pitch and a metal cap.

Function of Manganese Dioxide - When electric current is being drawn from the cell the ammonium chloride is split into hydrogen, ammonia and chlorine. These gases are the cause of polarization, the chlorine attaching to the zinc can and forming zinc chloride, the ammonia combining with the zinc chloride to form double salts of zinc and ammonium chloride. The hydrogen which collects as a non-conductive film on the carbon electrode is depolarized by the manganese dioxide almost instantaneously, probably while the hydrogen is still nascent, and forms  $Mn_2O_3 \cdot H_2O$ . This depolarizing action makes possible the continuous flow of current within the battery.

Characteristics of Manganese Ore - Several factors control the suitability of manganese ore for dry-cell manufacture. Chemically, the ore should have a high oxygen availability and a minimum of iron and should be free of copper, nickel, cobalt, arsenic, and other metals electronegative to zinc. If these metallic impurities are present in insoluble form, their deleterious effects are limited to their being nonconductors; however, if they are soluble, their solutions diffuse to the zinc can, where they form small electrocouple areas causing useless corrosion of the zinc and consequent deterioration and destruction of the cell.

Physically the ore should be somewhat hard but porous. Since it is believed that the depolarizing action in the cell is a surface reaction, a porous ore is able to react throughout its mass and not only on the outer surface. Seemingly opposed to this belief is the fact that a coarsely ground ore reacts better than one finely ground. It is thought that the reason for this is that the coarsely ground ore can hold more of the electrolyte than ore finely ground. Due to their factors of porosity and electrolyte - containing capacity, it has been found that grading the fine and coarse particles of ore has a great influence on cell performance. Wad-type ores are therefore not desirable, since they do not lend themselves to efficient milling and grading.

Primary Sources of Battery Ore - Data on the imports of battery ore are not complete, since some of the ore is imported as either chemical-or metallurgical-grade ore and then is selected and bought for the battery industry after arrival in the United States. In general, battery ore is imported from the U. S. S. R. or Gold Coast.

On the following page is a table showing the foreign imports of battery-grade ore.

Table XVIII-5 FOREIGN IMPORTS, BATTERY-GRADE ORE, /1  
SHORT TONS

1941	36,074
1942	7,963
1943	37,551
1944	54,941
1945	86,551
1946	92,758
1947	65,756
1948	81,769
1949	77,284
1950	85,311
1951	<u>/2</u> 68,283
1952	
1953	
1954	
1955	

/1 Not complete figures, as some chemical-grade ore may have been imported under battery ore and some battery-grade may have been listed as metallurgical or chemical for importing.

/2 Preliminary

Domestic battery-grade ores have been produced in several areas throughout the United States; however, most of these have been relatively small, production-wise. In the past few years, the output of this ore has been confined to the Phillipsburg district in Montana, where the Trout Mining Division of American Machines & Metals, Inc. and the Taylor-Knapp Co. have been consistent producers.

On the following page is a table showing the domestic production, battery-grade manganese ore, short tons. Table XIX-6.

TABLE XIX-7. DOMESTIC PRODUCTION, BATTERY-GRADE  
MANGANESE ORE, SHORT TONS

Year	Montana	Arizona	California	Georgia	Total
1941	10,284	22	1,093		11,399
1942	9,521		2,856		15,737 /1
1943	9,238		3,444	22	12,804
1944	6,224				6,224
1945	8,042				8,042
1946	8,295				8,295
1947	6,189				6,189
1948	10,845				10,845
1949	14,983				14,983
1950	11,507				11,507
1951	/2 10,000				10,000 /2

/1 Montana and California produced an additional 3,033 tons of ore in 1942, which is included in the total but has not been designated as to source.

/2 Estimate

Quotation of the manganese content of various ores is not sufficient for the battery industry, since the manufacturer is interested in the amount of  $MnO_2$  present. The natural mineral  $MnO_2$  is called pyrolusite and contains about 63% manganese and 37% oxygen; therefore, the conversion factor of 63.25 may be applied to find the  $MnO_2$  content of an ore once the manganese content has been determined. A greater differential becomes immediately apparent when domestic production is compared with imports from the standpoint of  $MnO_2$  content.

On the following page is a table showing the amount of  $MnO_2$  contained in domestic and foreign battery-grade ores. Table XIX-7.

Table XVIII-7. MnO<sub>2</sub> CONTAINED IN DOMESTIC AND FOREIGN  
BATTERY-GRADE ORES

Year	Domestic			Foreign		
	Ore Tons	MnO <sub>2</sub> %	MnO <sub>2</sub> Tons	Ore Tons	MnO <sub>2</sub> %	MnO <sub>2</sub> Tons
1941	11,399	69.52	7,924	36,074	85.81	30,955
1942	15,737	61.75	9,718	7,963	83.87	6,679
1943	12,804	60.79	7,784	37,551	88.50	33,233
1944	6,224	66.72	4,153	54,941	89.70	49,282
1945	8,042	77.78	6,255	86,551	87.95	76,122
1946	8,295	66.82	5,543	92,758	86.29	80,041
1947	6,189	66.74	4,130	65,756	87.36	57,444
1948	10,845	66.21	7,180	81,769	88.33	72,227
1949	14,983	64.21	9,621	77,284	85.00	65,691
1950	11,507	66.02	75.79	85,311	85.20	72,685
1951	<u>/1</u> 10,000	<u>/1</u> 65.00	<u>/1</u> 65.00	<u>/2</u> 68.283	<u>/2</u> 86.39	<u>/2</u> 58.990
1952						
1953						
1954						
1955						

/1 Estimate

/2 Preliminary

Consumption of Battery Ore - As might be expected from the above data, the industry depends largely upon imported ores as its source of supply as indicated by the data on the following page. Table XIX-8.

Table XVIII-8 MANGANESE ORE CONSUMED AND YEAR-END STOCKS OF MANUFACTURES OF DRY CELLS, SHORT TONS

STOCKS OF MANUFACTURES OF EXPORTS

	Consumption			Total	Stocks			Total
	Domestic		Foreign		Domestic		Foreign	
	35-47%	47%+			35-47%+	47%+		
1941	4,052	7,590	26,342	37,983	485	3,032	39,148	42,665
1942	3,099	9,157	24,246	36,502	6,975	2,406	30,487	39,868
1943	5,449	7,731	25,924	39,104	5,200	1,172	38,895	45,267
1944	2,981	6,235	40,633	49,849	157	997	39,160	40,314
1945	<u>1</u>	7,844	50,999	58,843	<u>1</u>	1,107	35,383	36,490
1946		8,497	39,104	47,601		1,531	59,924	61,455
1947		6,727	39,629	46,356		919	43,275	44,194
1948		5,747	42,253	48,000		2,350	33,361	35,711
1949		3,747	30,722	34,469		1,219	37,629	38,848
1950		3,369	37,950	41,319		1,221	25,876	27,097
1951 <sup>2/</sup>		3,191	40,936	44,127		1,502	19,189	20,691
1952								
1953								
1954								
1955								

<sup>1/</sup> All grades

<sup>2/</sup> Preliminary

#### O. MANGANESE IN THE GLASS AND CERAMIC INDUSTRY

Virtually all materials used in manufacturing glass contain some iron, generally in the form of ferric oxide. This iron content, even in very small amounts, causes the glass to carry a pale green color, which becomes quite intense as the iron content increases. If a colorless glass is needed, this green effect must be counteracted by various decolorizers. In general, these decolorizers are manganese, cobalt, nickel, and selenium. Of these, manganese probably is used most commonly, as it permits the easiest control. The greatest drawback to the use of manganese is that it tends to turn purplish pink when light. Naturally this practically excludes manganese in plate glass. In general, the use of manganese is limited to window glass and bottle or container glass.

ticularly the sand. Quantities are measured in terms of pounds of manganese dioxide per thousand pounds of sand. The range of the amount used runs downward from a maximum of 10 to 15 pounds and may go as low as 2 pounds.

In the absence of any other coloring agents, manganese produces colors ranging from pink through violet and purple to black. Elimination of the green color caused by the iron is generally attributed to a chemical reaction in which the ferric oxide is oxidized to ferric silicate which gives glass an almost imperceptible straw-yellow tint.

Other oxidizing agents do not seem to be able to give this reaction, which tends to verify the theory that the decolorizing power of manganese may be due to some physical phenomenon.

In general, the grades of manganese ore used in the glass industry are similar to those used in the battery industry. A high ratio of manganese dioxide to iron is of course desirable, and some special glasses may require an ore with 90 percent manganese dioxide and 0.5 percent iron.

Siliceous pyrolusite is acceptable, but carbonaceous pyrolusite is not.

Generally the ore is used in a powdered form or in small lumps, the finer the granules the quicker the melting time. Both foreign and domestic ores have proved satisfactory.

Certain special uses of manganese may be found in producing colored lenses, filters, and decorative structural glass. One type of filter is relatively important due to its ability to prohibit the passage of infrared rays.

In the ceramics industry, small amounts of manganese are consumed in glazes and enamels to produce purple or black colors.

#### P. MANGANESE AS A DRIER IN PAINT

Manganese is the third principal drier in use throughout the paint industry. It is intermediate in most respects between lead and cobalt. Manganese is a powerful oxidation catalyst as compared to lead, and it is considerably more active as a promoter of polymerization than cobalt. In linseed oil one part by weight of m



metal in the form of a drier will produce approximately the same drying effect as five parts of lead. This ratio may vary when comparisons are made with other drying vehicles.

Manganese driers tend to the formation of oil films which dry rapidly on the surface and yet harden quite thoroughly throughout the film. Thus, in some measure, manganese combines the virtues of lead and cobalt. However, the films produced by the use of manganese driers tend to be very hard, brittle, and resinous. For many purposes this is no disadvantage, and the tendency can be taken advantage of through judicious admixture of other driers. Thus, where very hard durable films are desired on surfaces which will not permit the film to be bent in service, manganese is very useful. In floor varnishes, where hardness is a prerequisite, it is widely used, and in a multitude of paint products of every description manganese is used in combination with lead to secure a good combination of drying properties.

Manganese driers, regardless of soap base, ultimately produce a characteristic pinking, or brown stain, or discoloration in films containing them. It is possible to produce liquid manganese driers of relatively pale color, which when added to oils or enamels will produce relatively insignificant discoloration by the manganese metal present. However, all manganese driers ultimately discolor to much the same degree after the paint or enamel is applied and exposed to the atmosphere. This may not be absolutely true, but for all practical purposes it may be so considered.

Manganese is customarily used in much the same amounts as cobalt. In low percentages in the presence of high amounts of lead drier there is very little difference between cobalt and manganese. Thus, in a house-paint vehicle containing one-half percent lead metal based on the weight of oil, it makes little difference whether one uses with it three-hundredths of a percent of cobalt metal or three-hundredths of a percent of manganese metal. In either case the drying time will be much the same, and the one containing the manganese will have less tendency to wrinkle during drying. Since this behavior

characteristic, it is possible to use manganese driers in place of variety of applications. The principal limiting manganese imparts. However, improved of the present day are being used in white and in small amounts in white baking enamels.

## Q. MANGANESE IN THE ALUMINUM INDUSTRY

Manganese is alloyed with aluminum in relatively small amounts to add hardness and stiffness. The manganese does not enter into a true solution in aluminum but seems to be distributed along the grain boundaries of the metal, which is thought to be a factor in the stiffening effect of the element.

Almost all aluminum contains some manganese as a residual metal, but the highest proportion of manganese found in the major alloys is that in what is known as "35." This is produced in sheet form and used extensively in producing aluminum cooking ware. Without manganese, this metal would approximate "25" or commercially pure aluminum, which is soft and easily pounded out of shape.

Method alloying - In order to add manganese to aluminum, a master alloy is made up containing 5 percent manganese and 95 percent aluminum. This master alloy generally is cast in 50-pound bars or ingots, which contain 2.5 pounds of manganese, so that standard additions may be easily calculated for the final product.

The master alloy usually is made up at the primary aluminum plant and is subsequently added to aluminum to fill orders for specific types of metals. The process differs from steel practice wherein the alloying is done at the producing furnace.

The production of aluminum is held to one standard product at the primary level, and alloying elements are added after the production process is completed and not during some stage within the process. Consuming industries may order basic aluminum and several master alloys and, by applying a batch operation, proceed to make several different final types of aluminum alloy. This is not the rule in the steel industry, where the customer is generally supplied with the final alloyed product according to specifications.

Alloys added to aluminum fall into two groups, those with low melting points, which may be added direct, and those with high melting points, which must be added through master alloys. Copper and silicon may be added either way; however, manganese falls into the master-alloy group.

Homogenizing - Because manganese, as well as some of the other alloying elements, has a higher melting point than aluminum and does not go into a true liquid solution, a certain soaking period for the ingots

must be observed, varying in length of time and amount of heat according to the amount and type of alloy used. This soaking period is known as "homogenizing," since one of its purposes is to obtain even dispersal and dissolving of the manganese and other elements through the metal as well as to remove the cored casting structure in the ingot.

Form of Manganese Additions - In most aluminum products, iron is considered an undesirable element and is kept to a minimum. This makes it rather difficult for the industry to make use of the regular types of ferromanganese alloys, which would carry the iron into the aluminum in about a 1:6.5 ratio. Recourse is, therefore, made to a special low-iron grade of ferromanganese, with an analysis in a range of 85 to 90 percent manganese with a maximum of 2.0 percent iron. This alloy, for example, permits the introduction of manganese to "35" aluminum at 1.2 percent, somewhat less than 0.03 percent iron being carried along.

In recent years the commercial production of electrolytic manganese by Electro Manganese Corp. has enabled the aluminum industry to use almost pure manganese for alloying additions. Possibly the industry would use electrolytic manganese almost exclusively if it were not for the price differential and the lack of enough of the electrolytic product.

Amount of Manganese Consumed - No absolute figures are available at this time on the total consumption of manganese in aluminum, since it has been relatively small and probably will continue so even with a large aluminum expansion.

Persons in the aluminum industry have estimated that 80,000,000 to 100,000,000 pounds of manganese master alloy were produced in 1950. Taking 5 percent of the higher figure of 100,000,000 pounds as the proportion of manganese in the alloy, a figure of 5,000,000 pounds is obtained. Translated into tons, this comes to 2,500 tons of manganese metal or about 5,200 tons of a 48-percent manganese ore. Assuming an over-all use efficiency of 75 percent, this would amount to about 7,500 tons of ore in 1950.

During World War II, it was the experience of those in the industry that the amount of manganese consumed per unit of aluminum produced did not change appreciably upon shifting from peacetime to wartime production, so it may be assumed that any change in the quantity of manganese consumed would be related to the quantity produced.

Table XVIII-9. PROPERTIES OF ALUMINUM ALLOYS

Type	Composition	Form	Characteristics	Uses
3S	Al-1. Mn	Sheets & Wrought	Good formability welding properties; corrosion resistance; will braze with flux.	Cooking utensils; chemical handling; gasoline & oil storage.
4S	Al-1.2Mn-1. Mg	do.	Good formability; somewhat higher strength than 3S.	Generally same as 3S.
14S	Al-4.4Cu-0.8Si-0.8Mn-0.4Mg	Wrought	High strength & hardness; fair formability.	Heavy-duty forgings; aircraft fittings & structures; extrusions.
17S <u>1/</u>	Al-4. Cu-0.5Mg-0.5Mn	do.	Relatively high strength; good formability; good corrosion resistance.	Rivets; hardware; screw machine parts; aircraft fittings; structural applications.
54S <u>1/</u>	Al-4.5Cu-1.5 Mg-0.5Mn	do.	Similar to 17S but higher strength.	Similar to 17S.
25S	Al-4.5Cu-0.8Mn-	do.	Good forging & high strength.	Aircraft propellers; link rods; radial engine crank cases.
56S	Al-5.2Mg-0.1 Mn-0.1Cr	do.	Good corrosion resistance.	Wire products; rivets.
75S	Al-5.5Zn-2.5 Mg-1.5Cu-0.3 Cr-0.2Mn	do.	Very high strength; good corrosion resistance.	Aircraft structural parts.

Table XVIII-9. PROPRIETIES OF ALUMINUM ALLOYS (Cont'd.)

Type	Composition	Form	Characteristics	Uses
R 301	Al-4.5Cu-1.Si- 0.8Mn-0.4Mg	Wrought	High strength; good formability; good corrosion resistance.	Aircraft parts; as a base for clad aluminum.
(Clad with Al-1.Mg-0.7Si-0.5Mn)				
R 317	Al-4.Cu-0.6Mn- 0.6Mg-0.05Pb- 0.05Bi	Wrought	Good formability; good machining.	Forging & free-machining stock.
RedX-8	Al-8.Si-1.5Cu- 0.3Mg-0.3Mn	Cast	High stress resis- tance at elevated temperature;	Internal-combus- tion-engine cast- ings & machined parts.
RedX-13	Al-12Si-1.2Cu- 0.7Mn-0.7Mg	Cast	High strength at elevated tempera- tures, with low coefficient of expansion.	Engine pistons.

1/ Rivets made from 17S and 24S have high shear strength of 33,000 p.s.i. and 42,000 p.s.i. respectively. Both types require refrigeration to retard rapid age hardening at room temperature.

In order that certain combinations of characteristics can be had, a series of clad types has been produced under the name "Alclad". Some of the manganese-containing alloys are used in this group but are not listed separately.

Insofar as manganese is concerned, aluminum is an important consumer from a qualitative rather than a quantitative standpoint. The facilities for producing the grades of special ferroalloys and manganese metal may be pushed to extremes if the aluminum industry were suddenly expanded, particularly if such expansion took place at a time when steel production was expanding and shifting to the higher alloy types, as ordinarily happens in a war emergency.

## R. MANGANESE AS AN ALLOY IN MAGNESIUM

Aluminum, manganese, and zinc are the principal alloys of magnesium, ranging in importance in the above order. Aluminum is by far the major alloy, being used in quantities up to 12 percent to improve mechanical qualities and formability. Zinc is employed in most of the newer alloys up to 3 percent to improve mechanical properties and resistance to corrosion.

Manganese is almost always used as an alloy in amounts up to 1.5 percent owing to its action in stiffening and hardening the magnesium. A certain amount of corrosion resistance is also attributed to manganese, in addition to the advantages in mechanical properties. The alloy containing 1.5 percent manganese as the only hardening element is used for sheets and extruded bar where lightness, formability, and corrosion resistance are essential factors, as in aircraft gasoline tanks, engine cowlings, and fuel-line fittings.

Manganese and magnesium will alloy only partly and with some difficulty owing to the difference in melting points. Aluminum, zinc, and sometimes beryllium are alloyed by immersing a quantity of the high-purity element in the molten bath. Since the melting point of manganese is so far above that of magnesium, it cannot be added as an element and is therefore added as a flux. Most of the elements in these fluxes are chlorides, with the exception of magnesium and calcium, which appear as an oxide and a fluoride, respectively. Fluxes are available in different compositions to provide for different alloys and for variations in the manufacturing process.

Two fluxes containing manganese are:

Dow Chemical No.	KCl	CaF <sub>2</sub>	MnCl <sub>2</sub> <u>1</u>	MgO
#250	23.0	2.5	72.00	
#320	---	13.0	76.00	11.0

1/ MnCl<sub>2</sub> contains 44 percent manganese.

An average manganese recovery of 80 percent is attained through this method of addition.

The amount of manganese consumed by the magnesium industry is small in relation to the total consumption and differs from the

steel industry in that chemical compounds of manganese are used rather than ferro-alloys or manganese metal.

## S. MISCELLANEOUS MANGANESE COMPOUNDS

Manganese Chloride - Preparation:  $\text{MnCl}_2$  may be made by the action of hydrochloric acid on manganese dioxide, with chlorine as a byproduct.

Uses:  $\text{MnCl}_2$  is a red, deliquescent salt and may be used in dyeing textiles, particularly cotton. The fabric to be dyed is soaked in the salt solution and then rinsed in a caustic alkali bath precipitating manganese hydroxide which turns brown upon oxidation. Further dyeing may be done with aniline black.

Manganese Sulfate - Preparation:  $\text{MnSO}_4$  may be prepared by heating the dioxide with ferrous sulphate and extracting with water.

Uses: The pink crystals of  $\text{MnSO}_4$  are highly soluble in water and can be used as a coloring agent in textile dyeing and porcelain painting. The salt may be used directly as a paint drier or may be used to produce other manganese compounds, which are also used as driers. The use of manganese sulfate as a fertilizer is discussed elsewhere in the report under the subject of fertilizers.

Manganic Persulfate - Preparation:  $\text{Mn}(\text{SO}_4)_2$  may be prepared electrolytically in the presence of sulfuric acid.

Uses: The compound has very high oxidizing powers and is sometimes used as an oxidizing agent in the manufacture of organic compounds.

Potassium Permanganate - Preparation: A solution of caustic potash ( $\text{KOH}$ ) is mixed with powdered manganese dioxide in the presence of an oxidizing agent such as potassium chlorate. The whole is heated and evaporated with the potassium permanganate  $\text{K}_2\text{MnO}_4$ , finally dissolved out with boiling water through which is passed chlorine, carbon dioxide or ozone. The potassium permanganate is crystallized out of solution and extracted.

Uses: Potassium permanganate may be used as a wood preservative and a textile bleach. Due to its oxidizing powers it may be used to disinfect or as a purifier of various gases.

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## XIX. CONSUMERS OF ORES



CHAPTER XIX. CONSUMERS OF MANGANESE ALLOYS -  
UNITED STATES

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XIX. CONSUMERS OF MANGANESE ALLOYS - UNITED STATES

STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Allegheny-Ludlum Steel Corp.  
2020 Oliver Bldg.  
Pittsburg, 22, Pa.

Brackenridge, Pa.  
Buffalo, N. Y.  
Dunkirk, N. Y.  
Watervliet, N. Y.

American Locomotive Co.  
Schenectady, N. Y.

Latrobe, Pa.

Armco Steel Co.  
Middletown, Ohio

Ashland, Ky.  
Butler, Pa.  
Middletown, Ohio

Atlantic Steel Co.  
P. O. Box 1714  
Atlanta 1, Ga.

Bethlehem Steel Co.  
Bethlehem, Pa.

Bethlehem, Pa.  
Johnstown, Pa.  
Lackawanna, Pa.  
Sparrows Point, Md.  
Steelton, Pa.

Bethlehem Pacific Coast Steel Corp.  
Bethlehem, Pa.

Los Angeles, Calif  
S. San Francisco, Calif.  
Seattle, Wash.

Central Iron & Steel Co.  
Harrisburg, Pa.

Colonial Steel Co.  
Monaca, Pa.

Colorado Fuel & Iron Corp.  
Pueblo, Colo.

Continental Steel Corp.  
Kokomo, Ind.



STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Crucible Steel Co. of America  
405 Lexington Ave.  
New York, N. Y.

All plants

Edgewater Steel Co.  
Oakmont, Pa.

Empire Steel Corp.  
Mansfield, Ohio

Firth-Sterling Steel & Carbide Corp.  
McKeesport, Pa.

Follansbee Steel Corp.  
Follansbee, W. Va.

Ford Motor Co.  
3000 Schaefer Road  
Dearborn, Mich.

Granite City Steel Co.  
Granite City, Ill.

Harrisburg Steel Corp.  
10th & Herr Sts.  
Harrisburg, Penna.

Heppenstall Co.  
4620 Hatfield St.  
Pittsburg, Pa. 1

Inland Steel Co.  
Chicago 3, Ill.

Indiana Harbor, Ind.

Jones & Laughlin Steel Corp.  
3d Ave. & Ross St.  
Pittsburgh 30, Pa.

Aliquippa, Pa.  
Otis Works, Cleveland, O.  
Pittsburgh, Pa.

ring & Supply Co.  
, Ind.

STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Kaiser Steel Corp.  
P. O. Box 217  
Fontana, Calif.

Judson Steel Corp.  
Emeryville, Calif.

Deystone Steel & Wire Co.  
Peoria 7, Ill.

Laclede Steel Co.  
1317 Arcade Building  
St. Louis 1, Mo.

Lukens Steel Co.  
Coatesville, Pa.

Midvale Co.  
Nicetown, Phila. 40, Pa.

National Steel Corp.  
2800 Grant Building  
Pittsburg 19, Pa.

Great Lake Steel Corp.  
Weirton Steel Co.

Newport Steel Corp.  
Newport, Ky.

Northwestern Steel & Wire Co.  
Sterling, Ill.

Pittsburg Steel Co.  
P. O. Box 118  
Pittsburgh 30, Pa.

Monessen, Pa.

**STEEL-INGOT PRODUCERS,  
COMPANY-MAIN OFFICE**

**LOCATION OF PLANT**

**Republic Steel Corp.**  
Republic Building  
25 Prospect Ave. N. W.  
Cleveland, Ohio

Alabama City, Ala.  
Birmingham, Ala.  
Buffalo, N. Y.  
Canton, Ohio  
South Chicago, Ill.  
Cleveland, Ohio  
Massillon, Ohio  
Troy, N. Y.  
Warren, Ohio  
Youngstown, Ohio

**John A. Roebling's Sons Co.**  
Trenton 2, N. J.

Roebling, N. J.

**Rotary Electric Steel Co.**  
Detroit 20, Mich.

**Sharon Steel Corp.**  
Sharon, Pa.

Lowellville, Ohio  
Farrell, Pa.

**Sheffield Steel Corp.**  
Kansas City 3, Mo.

Houston, Tex.  
Kansas City, Mo.  
Sand Springs, Okla.

**Stanley Works**  
American Tube & Stamping Co.  
Bridgeport, Conn.

**n Steel & Tube Co.**  
ton 6, Ohio

**Steel Corp.,**  
ries  
450 7th Ave.  
Pittsburgh 30, Pa.

**Universal-Cyclops Steel Corp.**  
Bridgeville, Pa.

**Washburn Wire Co.**  
Phillipsdale, R. I.

STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Wheeling Steel Corp.  
Wheeling, W. Va.

Benwood, W. Va.  
Steubenville, Ohio

Detroit Steel Corp.  
Portsmouth, Ohio

Colorado Fuel & Iron Corp.  
Buffalo, N. Y.

Wisconsin Steel Works  
2701 E. 106th St.  
Chicago 17, Ill.

Alan Wood Steel Co.  
Conshohocken, Pa.

Ivy Rock, Pa.

Woodward Iron Co.  
Woodward, Ala.

Worth Steel Co.  
Claymont, Del.

Youngstown Sheet & Tube Co.  
Stambaugh Building  
Youngstown 1, Ohio

Campbell Works, Camp-  
bell, Ohio  
Ind. Harbor Works,  
E. Chicago, Ind.  
Brier Hill Works,  
Youngstown, Ohio

Babcock & Wilcox Tube Co.  
Beaver Falls, Pa.

Braeburn Alloy Steel Corp.  
Braeburn, Pa.

A. M. Byers Co.  
Pittsburgh 30, Pa.

Carpenter Steel Co.  
Reading, Pa.

STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Connors Steel Co.  
Birmingham 1, Ala.

Copperweld Steel Co.  
Warren, Ohio

Henry Disston & Sons, Inc.  
Tacony,  
Philadelphia 35, Pa.

Erie Forge & Steel Co.  
Erie Forge Co.  
15th & Cascade Sts.  
Erie, Pa.

Ingersoll Steel Div.  
New Castle, Ind.

Jessop Steel Co.  
Washington, Pa.

Latrobe Electric Steel Co.  
Latrobe, Pa.

Mesta Machine Co.  
West Homestead, Pa.

National Forge & Ordnance  
Irvine, Pa.

The National Supply Co.  
Torrance, Calif.

Newport News Shipbuilding & Drydock Co.  
Newport News, Va.

Rolling Mill, Inc.  
N. W.

STEEL-INGOT PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Oregon Steel Mills  
5250 N. W. Front Ave.  
Portland 10, Oreg.

Pacific States Steel Corp.  
Niles, Calif.

Rustless Iron & Steel Div. of  
American Rolling Mill Co.  
Baltimore 13, Md.

Simonds Saw & Steel Co.  
Lockport, N. Y.

Standard Steel Works  
Burnham, Pa.

Texas Steel Co.  
Fort Worth, Tex.

Union Electric Steel Corp.  
2314 Oliver Building  
Pittsburgh 22, Pa.

Vulcan Crucible Steel Co.  
Aliquippa, Pa.

MANUFACTURES OF DRY CELL BATTERIES;  
COMPANY- MAIN OFFICE

LOCATION OF PLANT

Bright Star Battery Co.  
Clifton, N. J.

Acme Battery Co.  
59 Pearl St.  
Brooklyn, N. Y.

Burgess Battery Co.  
Freeport, Ill.

MANUFACTURES OF DRY CELL  
BATTERIES;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

General Dry Batteries, Inc. Cleveland, Ohio	All plants, Cleveland, Ohio
Lancaster Carbon Co. c/o Ray-O-Vac Co. Madison, Wis.	Lancaster, Ohio
E. J. Lavino & Co. 1528 Walnut St. Philadelphia 2, Pa.	
Marathon Battery Co. Wausau, Wis.	
National Carbon Co. Div. of Union Carbide & Carbon C. c/o H. C. Mehl 30 East 42d St. New York, N. Y.	Cleveland and Freemont, O.
Ray-O-Vac Co. Madison, Wis.	Madison, Wis. Sioux City, Iowa South Williamsport, Pa.
Underwood Battery Co. Cleveland, Ohio	
Union Carbide & Carbon Corp. 30 East 42d St. New York, N. Y.	Port Richmond, Phila. Pa.
U. S. Electric Mfg. Corp. 222 West 14th St. New York, N. Y. 11	
Winchester Repeating Arms Co. New Haven 4, Conn.	

MANUFACTURES OF CHEMICALS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANTS

Carus Chemical Co., Inc.  
1377 Eighth St.  
La Salle, Ill.

E. I. Dupont de Nemours & Co.  
Dupont Building  
1007 Market St.  
Wilmington 98, Del.

New Brunswick, N. J.

Electro Manganese Corp.  
Knoxville, Tenn.

Foote Mineral Co.  
18 W. Cheltenham Ave.  
Philadelphia 44, Pa.

Harshaw Chemical Co.  
Cleveland 6, Ohio

Merck & Co., Inc.,  
Lincoln Ave.  
Rahway, N. J.

A. O. Smith Corp.  
Milwaukee 1, Wis.

Tennessee Corp.  
East Point, Ga.

Tennessee Eastman Corp.  
Kingsport, Tenn.

Verona Chemical Co.  
Newark, N. J.

Zinsser & Co.  
Hastings-on-Hudson, 6, N. Y.



MANGANESE SULFATE PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Armour Fertilizer Works  
Atlanta, Ga.

Chesapeake Chemical Co.  
Crescent & Monument Sts.  
Baltimore, Md.

C. C. Daugherty  
Siler City, N. C.

Manganese Co.  
Anniston, Ala.

Manganese Products, Inc.  
Seattle, Wash.

North Cove Manganese Co.  
Marion, N. C.

Sulfate Products Corp.  
Dallas, Tex.

Virginia-Carolina Chemical Co.  
627 E. Main St.  
Richmond 8, Va.

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Adirondack Foundries & Steel, Inc.  
Watervliet, N. Y.

Allied Steel Casting Co.  
146th & Lincoln Sts.  
Harvey, Ill.

Alloy Steel & Metals Co.  
1862 E. 52d St.  
Los Angeles 11, Calif.

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

American Brake Shoe Co.  
230 Park Ave.  
New York 17, N. Y.

All plants, N. Y.

American Cast Iron Pipe Co.  
Birmingham 2, Ala.

American Chain & Cable Co., Inc.  
929 Conn. Ave.  
Bridgeport, Conn.

E. York, Pa.  
Reading, Pa.  
Monessen, Pa.

American Foundry & Machine Co.  
870 S. 4th West St.  
Salt Lake City, Utah

The Atlantic Foundry Co.  
182 Beaver St.  
Akron, Ohio

American Steel Foundries  
410 North Michigan Ave.  
Chicago 11, Ill.

Alliance, Ohio  
Newark, N. J.  
Granite City, Ill  
Ind. Harbor Works,  
E. Chicago, Ind.  
E. St. Louis, Ill.  
Verona, Pa.

The Atlantic Steel Castings Co.  
Chester, Pa.

Atlas Steel Casting Co.  
1963 Elmwood Ave.  
Buffalo 7, N. Y.

Auto Specialties Mfg. Co.  
St. Joseph, Mich

Riverside Road plant

Bay City Electric Steel Casting Co.  
Bay City, Mich

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Belle City Malleable Iron Co., & Racine Steel Castings Co. Racine, Wis.	
Birdsboro Steel Foundry & Mach. Co. Birdsboro, Pa.	Birdsboro, Pa.
Blaw-Knox Co. Bank Building Pittsburgh 22, Pa.	Lewis Foundry & Mach. Div. National Alloy Steel Div. Pittsburgh Rolls Division Union Steel Castings Div.
Bonney-Floyd Co. Columbus 7, Ohio	
Boston Electro Steel Castings, Inc. 53 Gerard St. Roxbury 19, Mass.	
Buckeye Steel Castings Co. 2211 Parsons Ave. Columbus 7, Ohio	
Bucyrus-Erie Co. South Milwaukee, Wis.	S. Milwaukee, Wis.
Burnside Steel Foundry Co. Chicago 19, Ill.	
Calumet Steel Castings Corp. Hammond, Ind.	
Chicago Steel Foundry Co. 3720 So. Kedzie Ave. Chicago 32, Ill.	
Cincinnati Steel Castings Co. 3216 Spring Grove Ave. Cincinnati 25, Ohio	
Clark Equipment Co. Buchanan, Mich.	

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Columbia Steel Casting Co.  
734 N. E. 55th Ave.  
Portland 13, Ore.

Continental Foundry & Mach. Co.  
144th St. & Railroad Ave.  
East Chicago, Ind.

Crucible Steel Casting Co.  
Almire & W. 84th St.  
Cleveland 2, Ohio

Damascus Steel Casting Co.  
New Brighton, Pa.

Dayton Steel Foundry Co.  
Dayton, Ohio 1

Deemer Steel Casting Co.  
New Castle, Del.

Dodge Steel Co.  
6501 Tacony St.  
Philadelphia, Pa.

Electric Steel Casting Co.  
Indianapolis 8, Ind.

Electric Steel Foundry Co.  
Portland 10, Ore.

Electrocast Steel Foundry Co.  
Chicago 50, Ill.

Empire Steel Castings, Inc.  
Box 139  
Reading, Pa.

Coraopolis, Pa.  
East Chicago, Ind.  
Warwood, W. Va.  
Wheeling, W. Va.

Cleveland, Ohio  
Lansdowne, Pa.  
Milwaukee, Wis.

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Falk Corp. Milwaukee 8, Wis.	
Farrell-Cheek Steel Co. Sandusky, Ohio	
The Frog Switch & Mfg. Co. Carlisle, Pa.	
General Electric Co. 1 River Road Schenectady, N. Y.	All plants, Schenectady, N. Y.
General Metals Corp. 701-105th Ave. Oakland 3, Calif.	
General Steel Castings Corp. Eddystone, Pa.	Granite City, Ill. Eddystone, Pa.
The Harrison Steel Castings Co. Attica, Ind.	
The Hartford Electric Steel Corp. Hartford 6, Conn.	Hartford, Conn.
Joy Manufacturing Co. Claremont, N. H.	
Kay-Brunner Steel Products, Inc. 999 Meridian Ave. Alhambra, Calif.	
Kensington Steel Co. 505 Kensington Ave. Chicago 28, Ill.	
Kincaid-Osburn Electric Steel Co. P. O. Drawer 2639 San Antonio 6, Tex.	

EEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

banon Steel Foundry  
Lebanon, Pa.

s Angeles Steel Casting Co.  
6100 So. Boyle Ave.  
Los Angeles 11, Calif.

ickintosh-Hemphill Co.  
Pittsburgh, Pa.

Pittsburgh, Pa.  
Midland, Pa.

e Massillon Steel Casting Co.  
Massillon, Ohio

aynard Electric Steel Casting Co.  
Milwaukee 7, Wis.

Conway & Torley Corp.  
Pittsburgh 1, Pa.

chigan Steel Casting Co.  
1986 Guoin St.  
Detroit 7, Mich.

lwaukee Steel Div.  
P. O. Box 443  
Milwaukee 1, Wis.

nnneapolis Electric Steel Castings Co.  
Minneapolis 13, Minn.

onroe Steel Casting Co.  
917 Front St.  
Monroe, Mich.

ountain State Steel Foundries  
Parkersburg, W. Va.

ational Erie Corp.  
Erie, Pa.

STEEL-CASTING PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Nat. Malleable & Steel Castings Co.  
Indianapolis 6, Ind.

Indianapolis, Ind.  
Cicero, Ill.  
Sharon, Pa.  
Cleveland, Ohio  
Melrose Park, Ill.

Nutmeg Crucible Steel Co.  
Branford, Conn.

Nye Tool Co.  
Galesburg, Ill.

Ohio Steel Foundry Co.  
Lima, Ohio

Springfield, Ohio  
Lima, Ohio

Oklahoma Steel Castings Co.  
Tulsa, Okla.

Olympic Steel Works  
151 Horton St.  
Seattle 4, Wash.

Pacific Car & Foundry Co.  
Renton, Wash.

Penn Steel Castings Co.  
Chester, Pa.

Pennsylvania Electric Steel Casting Co.  
Hamburg, Pa.

Pettibone Mulliken Corp.  
4710 W. Division St.,  
Chicago 51, Ill.

Pittsburgh Steel Foundry Corp.  
Glassport, Pa.

Fort Pitt Steel Casting Div.  
McKeesport, Pa.

Pratt & Letchworth Co., Inc.  
189 Tonawanda St.  
Buffalo 7, N. Y.

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Reliance Steel Castings Co.  
28th & Smallman Sts.  
Pittsburgh 22, Pa.

Ross-Meehan Foundries  
1601 Carter St.  
Chattanooga 1, Tenn.

Saginaw Foundries Co.  
Saginaw, Mich.

St. Louis Steel Castings Co.  
100 Mott St.  
St. Louis 11, Mo.

The Sawbrook Steel Casting Co.  
Lockalnd 15, Ohio

Scullin Steel Co.  
6700 Manchester Ave.  
St. Louis 10, Mo.

Sivyer Steel Casting Co.  
Milwaukee 14, Wis.

Milwaukee, Wis.  
& Chicago plants.

Sterling Steel Castings Co.  
P. O. 230  
E. St. Louis, Ill.

Specialty Steel Products Co.  
East Pittsburgh, Pa.

Braddock, Pa.

Strong Steel Foundry Co.  
33 Norris St.  
Buffalo 7, N. Y.

Superior Steel & Malleable Castings Co.  
Benton Harbor, Mich.

Swedish Crucible Steel Co.  
Detroit 11, Ill.



STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Symington-Gould Corp. Depew, N. Y.	Depew, N. Y.
Taylor Wharton Iron & Steel Co. Cincinnati 12, Ohio	High Bridge, N. J.
Texas Electric Steel Casting Co., Inc. P. O. Box 1418 Houston 1, Texas	
Union Spring & Manufacturing Co. New Kensington, Pa.	
Unitcast Corporation Toledo, Ohio	Plant No. 1 " " 3
United Engineering & Foundry Co. Pittsburgh, Pa.	Canton, Ohio New Castle, Pa. Vandergrift, Pa.
Utility Steel Casting Co. 3608 Terminal Annex Los Angeles 54, Calif.	
Valley Steel Casting Co. Bay City, Mich.	
Walworth Co. New York, N. Y.	
Washington Iron Works Seattle, Wash.	
Wehr Steel Co. 5234 W. Mobile St. Milwaukee 1, Wis.	
West Michigan Steel Foundry Co. Muskegon, Mich.	

STEEL-CASTINGS PRODUCERS;  
COMPANY-MAIN OFFICE

LOCATION OF PLANT

Western Alloyed Steel Casting Co.  
2901 Pleasant Ave.  
Minneapolis 8, Minn.

The West Steel Casting Co.  
805-853 East 70th St.  
Cleveland 3, Ohio

Cleveland 3, Ohio  
Seattle, Wash.  
Tacoma, Wash.  
Portland, Oreg.

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

Aluminum

Location of Plant

Aluminum Co. of America.  
501 Gulf Building  
Pittsburgh, Pa.

Massena, N. Y.  
Alcoa, Tenn.  
Badin, N. C.  
Vancouver, Wash.  
Port Comfort, Tex.

Reynolds Metals Co.  
Richmond, Va.

Listerhill, Ala.  
Longview, Wash.  
Jones Mills, Ark.  
Troutdale, Oreg.

Kaiser Aluminum & Chemicals Co.  
Kaiser Building  
Oakland, Calif.

Tacoma, Wash.  
Spokane, Wash.

Battery Companies

Bright Star Battery Co.  
Clifton, N. J.

Acme Battery Co.  
59 Pearl St.  
Brooklyn, N. Y.

Burgess Battery Co.  
Freeport, Ill.

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

<u>Battery Companies</u>	<u>Location of Plant</u>
General Dry Batteries, Inc. Cleveland, Ohio	Cleveland, Ohio Carrollton, Ohio Budugue, Iowa Memphis, Tenn.
Lancaster Carbon Co. c/o Ray-O-Vac Co. Madison, Wis.	Lancaster, Ohio
Marathon Battery Co. Wausau, Wis.	
National Carbon Division Union Carbide & Carbon Corp. P. O. Box 6087 Cleveland 1, Ohio	Cleveland, Ohio Freemont, Ohio
Ray-O-Vac Co. Madison, Wis.	Madison, Wis. Sioux City, Iowa South Williamsport, Pa.
Union Carbide & Carbon Co. Ore and Metals Division 30 East 42d Street New York, N. Y.	Port Rickmond, Phila. Pa.
Winchester Repeating Arms Co. Division of Olin Industries Co. New Haven 4, Conn.	
Copper Co. ation	Detroit, Mich. Decatur, Ala.

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL- UNITED STATES

<u>Brass and Bronze</u>	<u>Location of Plant</u>
Rivere Copper and Brass, Inc. 230 Park Ave. New York, N. Y.	Low Angeles, Calif. Chicago, Ill. Baltimore, Md. New Bedford, Mass. Detroit, Mich. Rome, N. Y.
American Brass Co. Waterbury, Conn.	Waterbury, Conn. Ansonia, Conn. Torrington, Conn. Detroit, Mich. Buffalo, N. Kenosha, Wis.
Bridgeport Brass Co. 30 Grand St. Bridgeport 4, Conn.	Bridgeport, Conn. Indianapolis, Ind.
Bridgeport Rolling Mills Co. P. O. Box 818 Bridgeport 1, Conn.	
Bristol Brass Corp. 580 Broad St. Bristol, Conn.	
Chase Brass & Copper Co., Inc. 236 Grand St. Waterbury 91, Conn.	Waterbury, Conn. Cleveland, Ohio
International Silver Co. Meridan, Conn.	
Miller Co. 99 Main St. Seymour, Conn.	
Plume & Atwood Manufacture Co. East Main St. Thomaston, Conn.	

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

<u>Brass and Bronze</u>	<u>Location of Plant</u>
Scovill Manufacture Co. 99 Mill Street Waterbury 99, Conn.	Waterbury, Conn.
Seymour Manufacture Co. Seymour, Conn.	
Stanford Rolling Mills Co. Springdale, Conn.	
Waterbury Rolling Mill Waterbury 89, Conn.	
Winchester Repeating Arms Co. Division of Olin Industries New Haven 4, Conn.	
Western Brass Mills Division of Olin Industries East Alton, Ill.	
Western Electric Co., Inc. Hawthorne Works 195 Broadway New York 7, N. Y.	Chicago, Ill.
New England Brass Co. Park St. Taunton, Mass.	
Detroit Gasket & Manufacture Co. Estruded Metals Division Belding, Mich.	
Hoskins Manufacturing Co. Lawton Ave. and Buchanan St. Detroit 8, Mich.	

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

Brass and Bronze

Location of Plant

Mueller Brass Co.  
1925 Lapeer Ave.  
Port Huron, Mich.

Wilbur B. Driver Co.  
150 Riverside Ave.  
Newark 4, N. J.

Eastwood Nealley Corp.  
28 Joralemon St.  
Belleville 9, N. J.

Riverside Metal Co.  
1 Pavillion Ave.  
Riverside, N. J.

Triangle Conduit & Cable Co., Inc.  
Triangle and Jersey Aves.  
New Brunswick, N. J.

Volco Brass & Copper Co.  
Kenilworth, N. J.

Phelps Dodge Copper Products Corp.  
40 Wall St.  
New York, N. Y.

Beryllium Corp.  
P. O. Box 1462  
Reading, Pa.

Electric Materials Co.  
Clay and Washington Sts.  
North East, Pa.

C. G. Hussey & Co.  
Division of Copper Range Co.  
2850 Second Ave.  
Pittsburgh 19, Pa.

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

<u>Brass and Bronze</u>	<u>Location of Plant</u>
Reading Tube Corp. 36-12 47th Ave. Long Island City 1, N. Y.	Reading, Pa.
Titan Metal Manufacturing Co. Bellefonte, Pa.	
Ampco Metal, Inc. 1745 S. 38th St. Milwaukee 4, Wis.	
Bohn Aluminum & Brass Co. Brass Mill 1400 Lafayette Building Detroit 26, Mich.	
<u>Chemical Company</u>	
Carus Chemical Co., Inc. 1377 8th St. LaSalle, Ill.	
E. I. DuPont de Nemours & Co. Methods Division Dupont Building 1007 Market St. Wilmington 98, Del.	Deepwater, N. J. New Brunswick, N. J.
Electro Manganese Corp. Knoxville, Tenn.	
Footo Mineral Co. 18 W. Chelton Ave. Hila. 44, Pa.	Exton, Pa.
Co., Inc. In Ave. ay, N. J.	

CONSUMERS OF MANGANESE ORES, ALLOYS, AND  
METAL - UNITED STATES

<u>Chemical Company</u>	<u>Location of Plant</u>
Tennessee Corp. East Point, Ga.	
Tennessee Eastman Corp. Kingsport, Tenn.	
Verona Chemical Co. Verona and Riverside Aves. Newark, N. J.	
Zinsser & Co. Hastings-on-Hudson, N. Y.	
Chesapeake Chemical Co. Crescent and Monument Sts. Baltimore, Md.	
Manganese Co. Anniston, Ala.	
Manganese Products, Inc. Seattle, Wash.	
Virginia-Carolina Chemical Co. 627 E. Main St. Richmond 8, Va.	





XX. DOMESTIC ORE PRODUCERS 1942-1945



## CHAPTER XX DOMESTIC ORE PRODUCERS, 1942-45

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Following are lists, by States, of the most active domestic manganese ore producers, during the World War II period, 1942-45, inclusive. Wherever known, the name and location of the mine and the name of the last operator are given. The class or classes of ore produced at each mine are shown by listing production under the respective headings for ores of 35 percent, or more, manganese content, 10 to 35 percent manganese content, and less than 10 percent manganese content. Annual output over 1,000 tons is indicated by XXX; from 100 to 1,000 tons by XX; below 100 tons by X.

Most Active Domestic Mines by Location,  
Owner, and Production, 1942-45, Inclusive

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
Calhoun	Unknown	Advance Mining Co., Jacksonville, Ala.			X
Do.	Do.	Chulatinee Ore Corp. Anniston, Ala.		X	
Unknown	Do.	W. C. Pope R. 1 Spring Garden, Ala.	---Unknown---		
Do.	Do.	J. B. Bynum Walnut Grove, Ala.	---	Do.	---

Arizona

Cochise	Tombstone Dev. Co.	Tombstone Dev. Co. Tombstone, Ariz.	X	XX	
Coconino	Unknown	Mining Co. & Baxter and Denison 1164 E. College St. Batesville, Ark.	XX		

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Arizona (Cont'd.)</u>					
Gila	American	American Manganese Co. 431 W. 7th St. Los Angeles 14, Calif.	XXX		
Do.	Apachie	Hutchinson & Owens P. O. Box 3015 Globe, Ariz.	XX		
Pima	Manganese King	C. E. Young, Trustee 1109 N. 1st St. Phoenix, Ariz.	XX		X
Mohave	Black Warrior & Big Jim	Norman W. McGregor Wenden, Ariz.	XX		X
Santa Cruz	Mawry	Grant & Woodruff 241 N. Westmoreland Los Angeles, Calif.	X		
Gila	New Dominion	T. L Long Globe, Ariz.			X
Mohave	Ariz. Man- ganese	O. W. Hogsett & R. Thompson P. O. Box 1686 Parker, Ariz.	X		
Gila	Mineral Farm & Globe Mn	Chris Miller Globe, Ariz.	X		
Do.	Rombo	Racine & Scholl P. O. Box 128 Globe, Ariz.	X		
Cochise	Copper Queen	Phelps-Dodge Bisbee, Ariz.			

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Arizona (Cont'd.)</u>					
Gila	Unknown	Apache Mines Corp. Miami, Ariz.	X		
Pinal	Manganese Queen	Robt. E. Vinson P. O. Box 202 Florence, Ariz.	X		
Santa Cruz	Fernando	Santa Cruz Mang. Inc. 2419 Los Amigos St. La Cresenda, Calif.	X		
Do.	Unknown	Patagonia Metal Mill, Inc. Patagonia, Ariz.	X	XX	
Navajo	Campbell & Denison	Campbell & Denison Cushman, Ark.	X		
Gila	Borg	Unknown	X		
Do.	Fierro	Do.	XX		
Do.	Globe	Al Stoval Globe, Ariz.	XX		
Santa Cruz	Bender No. 1	Unknown	X		
Yauapai	Victory	R. P. Cummings R. 3, Box 62 Phoenix, Ariz.	XX		
Yuma	Spring	Do.	XX		
Mohave	Artillery Peak	Manganese Ore Co. 1300 Leader Bldg. Cleveland, Ohio	---Unknown---		



<u>County</u>	<u>Mine</u>	<u>Last-known owner of operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Arkansas</u>					
Grants	Unknown	High Five Mining Co. Mena, Ark.	X		
Do.	Sugar Stick	Mena Mining Co. Mena, Ark.	X		
Independence	(Many)	The Denison Mang. Co. & Baxter & Denison 1164 E. College St. Batesville, Ark.	XXX	XXX	
Do.	Aydelotte	Arkansas Manganese Co. Cushman, Ark.	XXX	XXX	
Do.	Martha Thompson	S. Reece 620 Oram St. Dallas, Tex.			X
Do.	Consolidated	Consolidated Mining Co. Batesville, Ark.	X	XX	
Do.	Gray Hill	C. S. Little Box 337 Batesville, Ark.	XX	XX	
Do.	McBride	J. W. Barnes P. O. Box 503 Batesville, Ark.			X
Pike	Black Springs No. 1	North American Mang. Co. 408 Olive St. St. Louis, Mo.	XX		
Independence	Unknown	C. C. Sims Cushman, Ark.	XX	X	

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Arkansas (Cont'd.)</u>					
Independence	(Many)	Johnson & Hendricks Batesville, Ark.	XX	XX	
Do.	Turner	Lou Peterson	XX		
Do.	Southern Hill	Westmoreland Steel Co. Batesville, Ark.	XX		
Do.	Polk Southard	Davis Mining Interprice	XX		
Do.	Hunt No. 2	Pam Mar Eng. Co. 231 S. La Salle St. Chicago, Ill.			X
Unknown	Unknown	Southern Mining & Mang. Co. Cushman, Ark.	---Unknown---		
<u>California</u>					
Amador	Stacy	Jos. T. Stacy Pine Grove, Calif.	X		
Imperial	(Many)	V. B. Whedon 212 Bank of America Building Beverly Hills, Calif.	XX	XX	
Mendocino	Luck Boy	Car-Gor-Van Minerals Willito, Calif.	X		
Nevada	Duggan	C. A. Neville & G. B. Slater Unknown Address	X		
Plumas	Baito	Al Timmins Crescent Mills, Calif.	XX		

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>California (Cont'd)</u>					
Riverside	Arlington	Miner, Ranch & Ranch and Hall 11134 W. Washington Bend Culver City, Colo.	X	XXX	
Santa Clara	Winegar	P. Winegar Patterson, Calif.	X		
Do.	Pine Ridge	Alfred Jackson Morgan Hill, Calif.	XX		
Do.	Barker	Barker Corp. Box 696 Patterson, Calif	XXX		
Do.	Jones	Western Manganese Co. 519 Calif. St. San Francisco, Calif.		XXX	
Stanislaus	Buckeye	Verner Allen 156 Montgomery St. San Francisco, Calif.	XXX		
Do.	Liberty	Warren Mines 605 Market St. San Francisco, Calif.	XX	XX	
Do.	Tip Top	Tip Top Manganese Box 273 Patterson, Calif.	XX	X	
Trinity	Linseed & Coldwater	Rae F. Helmke Box 517 Garberville, Calif.	XX		
Do.	Manganese Queen	A. Granzotto Const. Co.	XX		

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>California Cont'd</u>					
Trinity	J. M. McKnight Grp.	James I. Scott Fortuna, Calif.	XX		
Siskiyou	Grey Ledge	Unknown	X		
San Bernardino	Hall Various small mines.	Mohave Mang. Co. P. O. Box 1864 Parker, Ariz.	XX	X	
San Joaquin	Mahoney	Unknown	X		
Stanislaus	Patterson Various small mines	do.	XX		
Shasta	Old Bill	do.	X		
San Luis Obispo	Stanuseich	do.	X		
Plumas	Haunganese	H. H. Hann Quincy, Calif.	X		
Do.	Iron Dyke & La Kevew	Western Mang. Mines 519 California St. San Francisco, Calif.	XXX		
Alameda	Wolfe & Aitken	F. L. Wolfe & A. C. Aitken 804 Kohl Bldg. San Francisco, Calif.	X	X	
San Joaquin	Johnson Manganese	A. W. V. Johnson 1007 Merchants Exch. Co. San Francisco, Calif.	XX		
Stanislaus	Western Man- ganese	Western Manganese Co. 519 Calif. St. San Francisco, Calif.	XX	X	

California (Cont'd)

Humbolt	Ft. Seward	Warren Mines 605 Market St. San Francisco, Calif.	XXX	
San Louis Obispo	Irish Hill	S. L. Elliott San Luis Obispo, Calif.	XX	
San Bernardino	Stewart	Mineral Materials Co. 1145 Westminster Ave. Alhambra, Calif.	X	
Trinity	Hale Creek	Western Metals Co. 326 Treat St. San Francisco, Calif.	XXX	
Stanislaus	Black Wonder	Del Puerto Mang. Co. 519 California St. San Francisco, Calif.		XX
Humbolt	Fort Baker	Unknown	XX	
Imperial	Whedon Mang. Mine	V. B. Whedon 212 Bank of America Building Beverly Hills, Calif.	XX	
Trinity	Lost	Unknown		XX
Alameda	No. 27	do.	X	
Riverside	Puritan	do.	X	
San Luis Obispo	Stanlisech	do.	X	
Do.	Unknown	Explorers, Inc.	X	
Do.	Unknown	Mitchell & Graves	X	

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grade of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Colorado</u>					
Saguache	Pershing	M. E. Bates & A. E. Reilly 220 Majestic Bldg. Denver, Colo.	XX		
Ouray	Whippoorwill	Hayden Mining Co. Box 1071 Colorado Springs, Colo.	XX		
<u>Georgia</u>					
Bartow	Bearden	Bearden & Mosteller Cartersville, Ga.	XX	XXX	
Do.	Hubrey	Neel & Neel Cartersville, Ga.	XXX	X	
Do.	Unknown	Neal Smith Cartersville, Ga.	X		
Do.	Appalachian	Appalachian Man- ganese Corp. P. O. Box 505 Cartersville, Ga.	XX	XXX	
Do.	Dobbins	Manganese Mining Co. 2212 S. 20th St. Birmingham, Ala.		XX	
Do.	Russel	G. E. Russel Cartersville, Ga.	X	X	
Do.	Blue Ridge	Blue Ridge Mining Co. Cartersville, Ga.	X	XXX	
Do.	New Riverside	New Riverside Ochrelo Cartersville, Ga.		XX	

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Georgia (Cont'd)</u>					
Lincoln	Cherokee	M. H. McKnight Cartersville, Ga.	XX	X	
Bartow	White	White Min. Co.			
<u>Massachusetts</u>					
Hampshire	Taconic	Anson G. Betts		XXX	
<u>Michigan</u>					
Iron	Bengal	Pickands Mather & Co.	XXX		XXX
Do.	Rogers	Hanna Iron Ore Co. Leader Bldg. Cleveland, Ohio			XX
<u>Minnesota</u>					
Crow Wing	Louise & Merritt	Butler Bros. 1300 Leader Bldg. Cleveland, Ohio		XXX	
Do.	Alstead- Hillcreast Arko Group	Hanna Coal & Ore Co. Crosby, Minn.			XXX
Do.	Hopkins	Evergreen Mines Co. Crosby, Minn.			XXX
Do.	Mahnomen	Pickands Mather & Co. Cleveland, Ohio			XXX
Do.	Sagamore	Do.			XXX

Missouri

Shannon	Rock Creek, Buckeye & Smokey Mtn.	Shannon Mining & Ore Co. Winona, Mo.	X	
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Montana

Granite	Moorlight Group	Taylor-Knapp Co. Philipsburg, Mont.	XX	
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Granite	Trout	Trout Mining Div. American Machine & Metals, Inc. Philipsburg, Mont.	XXX	XXX
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Silver Bow	Emma, Travona & Anselmo	Anaconda Copper Mng. Co. 25 Broadway New York, N. Y.	XXX	
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Granite	Silver Prince	Contact Mines Philipsburg, Mont.	XX	
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Do.	Redemption	Paul Henny	XX	
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Granite, Madison, Many Silver Bow		L. P. Tonner 1401 Texas Ave. Butte, Montana	XX	XX
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Unknown	Unknown	Domestic Manganese & Development Co. Butte, Mont.	---	Unknown---
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Nevada

Humbolt	Black Diablo	Galconda Mining Co. 601 Bridge St. Winnemucca, Nev.	XXX	XXX
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<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Nevada</u>					
Clark	Las Vegas Wash	Harlan H. Brandt		XX	
Lander	Black Rock	Western Alloys, Inc. 1455 5th East Salt Lake City, Utah	XX		
White Pine	Black Spot	G. O. Bradley	X		
Do.	Manganese	Manganese Mining Co. P. O. Box 486 Ely, Nev.	XXX	X	
Elko	Wicker	Mountain City Man. Co. Mountain City, Nev.	X		
Clark	Mill & Three Kids	Manganese Ore Co. 1300 Leader Bldg. Cleveland, Ohio	XXX	XX	
Unknown	Unknown	Charleston Hill National Mines 239 E. 3d St. Winnemucca, Nev.	---Unknown---		
Do.	Do.	F. Farnsworth Eureka, Nev.		Do.	
Do.	Do.	C. D. Ross Fallon, Nev.		Do.	
<u>New Mexico</u>					
Luna	Luna	Luna Manganese Co. Deming, N. Mex.	XX		
Grant	Boston Hill	Luck Mining & Construction Co. Silver City, N. Mex.		XXX	

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>New Mexico (Cont'd)</u>					
Valencia	Unknown	Good Luck Mining Co.	XX		
Sierra	National Defense Group	Jose Giron Good Luck Mining	X		
Socorro	(Mill)	Socorro Corp. 715 First National Bank Albuquerque, N. Mex.	---	Unknown---	
<u>Oklahoma</u>					
Unknown	McCurtain	Ouachita Mang. Co. Mena, Ark.	X		
<u>Oregon</u>					
Curry	McAdams	W. E. Warren Coquille, Oreg.	X		
<u>Tennessee</u>					
Johnson	Taylor	Butler Mining & Development Co. Box 328 Elizabethton, Tenn.		X	
Blount	Chilowee Mountain	N. T. Dixon	X		
Unicoi	Embree	Embree Iron Co. Emberville, Tenn.	XX	XX	
Do.	Glen Street	Tennessee Zinc Co. Embreeville, Tenn.	XX	XX	
Johnson	Shoun	Tennessee Develop- ment Co. P. O. Box 4 Mountain City, Tenn.	X		

<u>County</u>	<u>Mine</u>	<u>Last-known owner</u> <u>or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Tennessee (Cont'd)</u>					
Johnson	Shady Valley	Mountain City Ore Co. Mountain City, Tenn.	X		
Washington	Embree	Tennessee Zinc Co. Embreeville, Tenn.	XX	XX	
Do.	Unknown	Minerals Co. of Va.		XX	
Bradley	Hanebright	Consolidated High-Grade Ore Co. P. O. Box 532 Cleveland, Tenn.		XX	
Unknown	Unknown	The Dixie Mang. Min. Corp. 608 Hamilton Nat. Bank Bldg. Johnson City, Tenn.	--Unknown		
<u>Utah</u>					
Grand	Turner Group	Drury D. Turner	XX		
Juab	Black Boy	Fred Staas 29 S. State St. Salt Lake City, Utah		XXX	
<u>South Carolina</u>					
McCormick	Boykin Kelly & Dorn	Abernathy & Kenays McCormick, S. C.	XX		
Greenwood	Greenwood	H. M. Clegg Greenwood, S. C.		X	
<u>Virginia</u>					
Smyth	Unknown	Sugar Grove Mining Co. Marion, Va.	X		

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Virginia (Cont'd)</u>					
Smyth	Deans Br. & Curren Valley	G. S. Murray & Co. P. O. Box 646 Marion, Va.	X		
Pulaski	No. 33 Ocher	American Pigment Co. Hiwassee, Va.		X	
Unknown	Unknown	Mineral Co. of Va.		XX	
Bland	Shater Huddle	Unknown	X		
Do.	Stange	Biggam Min. Co. Bland Va.		XX	
Do.	Miller	Miller Mang. Co. 934 Bland St. Bluefield, Va.	X	X	
Augusta	Mine Bank	General Development Co. Vesuvius, Va.	X	XXX	
Bland	Flat Top	Row W. Arms Widesburg, Va.	XXX	XXX	
Do.	Stange	Biggam Mang. Co. Bland, Va.	XX	XX	
Do.	Vir. Hdwd. Lbr.	Virginia Hardwood Lumber Bastian, Va.	XXX	XX	
Craig	Red Brush	George M. Collard 812 Oliver Bldg. Pittsburg, Pa.	X		
Smyth	Deans Branch Curron Valley	N. T. Dixon	X		

<u>County</u>	<u>Mine</u>	<u>Last-known owner or operator</u>	<u>Grades of ore</u>		
			<u>35%</u>	<u>35-10%</u>	<u>10%</u>
<u>Virginia (Cont'd)</u>					
Smyth	Glade Mountain	Glade Mountain Corp. XXX P. O. Box 230 Marion, Va.			
Rockingham	Yancey Prop- erty Coatsville, Pa.	Allegheny Ore & Iron Co.	X		
Augusta	Old Dominion	Dominion Manganese XXX Co. 135 Broadway New York, N. Y.			

Washington

Clallam	Crescent	Sunshine Mining Co. Star R. 1 Port Angeles, Wash.	XXX		
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West Virginia

Monroe	Sweet Springs	Appalachian Ores Co. Sweet Springs, W. Va.	XX		
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Importers of Manganese Ore

African Metals Corp.	25 Broad St. New York 4, N. Y.
American Smelting & Refining Co.	Upriver Road Corpus Christi, Tex.
Associated Metals and Minerals Corp.	75 West St. New York 6, N. Y.
Basden & Basden	258 Broadway New York 7, N. Y.
Bethlehem Steel Co.	Bethlehem, Pa.

Importers of Manganese Ore

Bowlby & Co.	785 Market St. San Francisco, Calif.
Bowring & Co.	17 Battery Pl. New York 4, N. Y.
Bradley & Ekstrom	320 Market St. San Francisco 11, Calif.
Leonard J. Buck, Inc.	1 Newark Ave. Jersey City, N. J.
Electro Manganese Corp.	Knoxville 4, Tenn.
Electro Metallurgical Co.	Division of Union Carbide Corp. 30 East 42d St. New York, N. Y.
Ferro Traders	165 Broadway New York, N. Y.
M. Golodetz & Co.	120 Wall St. New York, N. Y.
Huxley-Westfried Corp.	350 Fifth Ave. New York, N. Y.
Intercontinental Trading Co.	12430 Ventura Court Studio City, Calif.
E. J. Lavino & Co.	1528 Walnut St. Philadelphia 2, Pa.
Manchard Trading Corp.	52 Vanderbilt Ave. New York 17, N. Y.
Wm. H. Muller & Co.	122 East 42d St. New York 17, N. Y.
Ore & Ferro Corp.	30 Broad St. New York 4, N. Y.
Philipp Bros., Inc.	70 Pine St. New York, N. Y.

Importers of Manganese Ore

Frank Samuel & Co., Inc.	Lincoln-Liberty Building Broad and Chestnut St. Philadelphia, Pa.
Sheffield Steel Co.	Kansas City 3, Mo.
Tennessee Eastman Co.	Division of Eastman Kodak Co. Kingsport, Tenn.
United States Steel Corp.	525 William Penn Pl. Pittsburgh 30, Pa.
Westinghouse International Development Co.	40 Wall St. New York, N. Y.







XXI. FERRO-ALLOY PRODUCERS - DOMESTIC & FOREIGN



## CHAPTER XXI. PRODUCERS OF FERRO-ALLOYS

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## XXI PRODUCERS OF FERRO-ALLOYS

### A. LATIN AMERICA

#### Brazil

- Active -
1. Cia. Eletro-Chimica Brasileira  
Soromenha, Minas Gerais
  2. Cia. Brasileira De Aços Finos  
Nova Iguaçu, Rio De Janeiro (State)
- Inactive -
1. Cia. De Aços Especiais Itabira  
Coronel Fabriciano (Municipality)  
Minas Gerais (State)
  2. Cia. Níquel Do Brasil  
Liberdade, Minas Gerais
  3. Cia. Nacional De Ferro Ligas  
Estádio, Honório, Distrito Federal

#### Chile

1. Cia. Nacional De Carburo Y Metalurgico  
Nos (State Unknown, probably near  
Santiago) Owned by Gianoli Mustakis  
and Co. with offices in Santiago, Chile.

#### Mexico

1. Siderurgica De Monterrey  
(Subsidiary of Cia. Fundidor De  
Hierro Y Acero De Monterrey, S. A.)  
Tapia Al Oriente  
Monterrey, Nueva Leon
2. Teziutlan Copper Co.  
Aire Libre, Puebla

#### Argentina

Sociedad Mixta Siderurgia Argentine  
San Nicolas (near Buenos Aires)

## B. UNITED STATES

The following is a list of those blast furnaces in the United States which are presently producing ferromanganese and spiegeleisen or which have produced ferromanganese and spiegeleisen in recent years.

### Bethlehem Steel Co.

Subsidiary of Bethlehem Steel Corp.  
25 Broadway  
New York 4, N. Y.

Chairman - E. G. Grace  
President - A. B. Homer  
V. P. Operations - S. J. Cort

Johnstown plant - Ferromanganese  
Johnstown, Pa.

				Cu. ft.			
Fce	Height	Hearth	Bosh	Stack volume	Rebuilt	Relined	Capacity, tons
F	85'-8"	18'-0"	22'-0"	21,578	1938	1946	90,000
H	86'-0"	17'-6"	22'-0"	21,884	1920	1947	90,000

### Other furnaces:

5 other blast furnaces producing pig iron with annual capacity of 1,498,000 tons.

### Stoves:

27 stoves with 3,210,000 sq. ft. heating surface.

### Blowing engines:

10 engines (4 steam, reciprocating, double; 6 turbo) with 520,000 c.f.m. with 25 lb. pressure.

2 complete gas-cleaning plants with cleaning towers, disintegrators, and moisture eliminators.

Pig machines:

Two Pittsburgh coal washer double-strand pig-casting machines.

Slag plants;

None

E. J. Lavino & Co.  
1528 Walnut St.  
Philadelphia 2, Pa.

President - E. M. Lavino  
V. P. Operations - John O. Lorange

Sheridan Plant - ferromanganese  
Sheridan, Pa.

Fce	Height	Hearth	Bosh	stack volume, cu. ft.	Rebuilt	Relined	Capacity, tons
1	78'-6"	12'-0"	16'-9"	10,990	1919	1946	36,000

Other furnaces:

None

Stoves:

5 stoves with 156,000 sq. ft. heating surface.

Blowing Engines:

3 steam blowing engines, 35,000 c.f.m., with 15 to 25 lb. pressure.

Gas-cleaning equipment:

None



Pig machines:

None.

Slag plants:

None.

Reusen's plant - ferromanganese  
Ruesen's, Va.

Fce	Height	Hearth	Bosh	Stock volume cu. ft.	Rebuilt	Relined	Capacity, tons
1	80'-6"	12'-0"	16'-6"	11,153	1919	1946	36,000

Other furnaces:

None.

Stoves:

5 stoves with 100,000 sq. ft. of heating surface.

Blowing engines:

3 steam blowing engines, 35 000 c.f.m. with 25 lb. pressure.

Gas-cleaning equipment:

None.

Pig machines:

None

Slag plants:

None

New Jersey Zinc Co.  
160 Front St.  
New York 7, N. Y.

President - H. Hardenbergh  
V. president - M. L. Havey

Palmerton plant - spiegeleisen  
Palmerton, Pa.

Fce	Height	Hearth	Bosh	Stack volume,	Rebuilt	Relined	Capacity, tons
				cu. ft.			
1	64'-8-1/8"	12'-6"	17'-0"	11,500	1917	1947	77,300
2	60'-5-3/4"	10'-0"	14'-10"	7,500	1928	1947	57,100

Other furnaces:

None

Stoves:

9 stoves with 78,250 sq. ft. heating surface.

Blowing engines:

3 steam-blowing engines, recuperating, double 56,000 c.f.m.  
with 25 lb. pressure.

Gas-cleaning equipment:

None

Pig machines:

1 single-strand pig-casting machine.

Slag plants:

4 slag-granulating pits, capacity 110,000 tons.

Sloss-Sheffield Steel & Iron Co.  
Birmingham, Ala.

Chairman - Hugh Morrow  
President - C. S. Lawson

Blast-furnace plant - ferromanganese  
North Birmingham, Ala.

Fce	Height	Hearth	Bosh	Stack volume, cu. ft.	Rebuilt	Relined	Capacity, ton
3	80'-10-3/4"	12'-8"	17'-10"	15,072	1938	1947	36,800

Other furnaces:

1 furnace on pig-iron production of 105,240-ton capacity.

Stoves:

10 stoves of 236,950 sq. ft. heating surface.

Blowing engines:

8 blowing engines (7 steam reciprocating, double; 1 turbo)  
128,000 c.f.m. with 20 lb. pressure.

Gas-cleaning equipment:

None

Pig machines:

1 Heyl & Patterson double-strand pig-casting machine.

Slag plant:

1 slag-granulating plant 48,000-ton capacity.

Tennessee Products & Chemical Corp.  
Nashville 3, Tenn.

Chairman - Paul M. Davis  
President - Carl McFarlin

Rockwood plant - ferromanganese  
Rockwood, Tenn.

Fce	Height	Hearth	Bosh	Stack volume, cu. ft.	Rebuilt	Relined	Capacity, to
1	78'-11"	12'-0"	16'-0"	10,740	1948	1948	33,600
2	79'-8"	12'-0"	16'-0"	10,917	---	1946	33,600

Other furnaces:

None

Stoves:

9 stoves with 44,000 sq. ft. heating surface.

Blowing engines:

6 steam-blowing engines, single, noncondensing 135,000 c.f.m.,  
with 15 lb. pressure.

Gas-cleaning equipment:

None

Pig machines:

None

Slag plant:

1 slag-granulating plant.

United States Steel Company  
525 William Penn Place  
Pittsburgh, Pa.

President - C. R. Cox  
V. P. Operations - J. E. Lose

Clairton Steel Works-- ferromanganese  
Clairton, Pa.

Fce	Height	Hearth	Bosh	Stack volume,	Rebuilt	Relined	Capacity, tons
				cu. ft.			
2	85'-3 1/2"	18'-6"	21'-8"	23,341	1903	1943	85,400
3	85'-7 3/4"	18'-0"	21'-8"	22,118	1903	1945	80,900

Other furnaces:

1 blast furnace on pig iron; annual capacity, 321,100 tons.

Stoves:

11 stoves, with 737,000 sq. ft. heating surface.

Blowing engines:

7 steam blowing engines, reciprocating, double, 234,500 c.f.m.,  
with 22 lb. pressure.

Gas-cleaning equipment:

None

Pig machines:

2 Heyl & Patterson double-strand pig-casting machines.

Slag plants

2 slag-granulating plants, annual capacity 370,000 tons.

Isabella furnaces - ferromanganese  
Etna, Pa.

Fce Height	Hearth	Bosh	Stack volume, cu. ft.	Rebuilt	Relined	Capacity, t
1 92'-11 1/4"	17'-0"	21'-6"	24,048	1902	1947	72,400
3 93'-0"	17'-0"	21'-6"	22,280	1902	1944	72,500

Other furnaces:

Rebuilding No. 3 at present, should be in blast early in 1951

Stoves:

11 stoves, 508,500 sq. ft. heating surface.

Blowing engines:

4 steam blowing engines, reciprocating, double, 134,000 c.f.m.,  
with 18 lb. pressure.

Gas-cleaning equipment:

None

Pig machines:

2 uehling double-strand pig-casting machines.

Slag plants:

2 slag-granulating plants, annual capacity 87,000 tons.

Other equipment:

1 ferromanganese briquetting plant, annual capacity 40,000 tons.

Subsidiary, Brown Marx Building  
Birmingham 2, Ala.

President - Robert Gregg  
V. P. Operations - A. V. Weibel

				Stack volume,			
Fce	Height	Hearth	Bosh	cu. ft.	Rebuilt	Relined	Capacity, tons
6	83'-0"	15'-0"	20'-4"	18,782	1931	1947	29,000

**Other furnaces:**

5 other blast furnaces producing pig iron, with an annual capacity of 1,360,600 tons.

**Stoves:**

32 stoves with 2,071,550 sq. ft. heating surface.

**Blowing engines:**

20 vertical steam-blowing engines, 4 turbo blowers, 582,000 c.f.m. with 25 to 35 lb. pressure.

**Gas-cleaning equipment:**

None

**Pig machines:**

1 Uehling double-strand pig-casting machine.

**Slag plants:**

None

The following pages list those electric furnaces producing manganese alloys as well as those producing other alloys. Many operations are interchangeable and plants may produce even a larger variety of alloys than are indicated.

#### Anaconda Copper Mining Company

25 Broadway  
New York 4, N. Y.

Anaconda and Black Eagle Plants  
Anaconda, Mont.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
4		3	Ferromanganese Standard	120,000

Power:

Supplied by Montana public utilities firms. Hydroelectric in origin. Transformer capacity is adequate and interchangeable.

#### Electro Metallurgical Co.

Owned by Union Carbide & Carbon Corp.  
30 East 42d St.  
New York 17, N. Y.

Niagara plant,  
Niagara Falls, N. Y.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrochrome alloys	73,700
			Ferrosilicon alloys	31,800
			Miscellaneous alloys	1,200

Power:

Hydro-electric power is supplied by Niagara Falls Power Co. No power generated at the plant. Full load, 1 hour, demand for plant operation is 111,000 kw., which can be met by present facilities. Transformer capacity is adequate for capacity operation and is interchangeable between furnaces.



## Virginia works

### Holcomb Rock, Va.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phase</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrochrome alloys	3,100

#### Power:

Hydro-electric power is generated at the plant. It is not known what, if any, facilities exist for purchasing additional power. Full load, 1 hour, demand for plant operation is 1,850 kw. Plant generating capacity is sufficient to cover about 75 percent of continuous full-load capacity. Under present operations, the plant is presumably working on batch-type processes which do not require a continuous full load. Transformer capacity is sufficient and interchangeable.

## Alloy works and Kanawha works

### Alloy and Glen Ferris, W. Va.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrochrome alloys	38,200
			Ferrosilicon alloys	70,800
			Ferromanganese alloys	82,240
			Miscellaneous alloys	12,300

#### Power:

Hydro-electric and steam power is generated at the plants. With the new generator capacity scheduled for activation in September 1950, the plants will produce about 96 percent of their continuous full load demand. Maximum 1 hour demand is 155,000 kw. Transformer capacity is sufficient and interchangeable between furnaces.

## Sheffield works

### Sheffield, Ala.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrosilicon alloys	69,600
			Ferromanganese alloys	31,200

## Power:

Hydro-electric power is purchased from the Tennessee Valley Authority, with none generated at the plant. Maximum 1 hour full load, demand is 60,000 kw. Power available is about 93 percent of continuous full-load demand. Transformer capacity is sufficient and interchangeable between furnaces.

## Ashtabula works

Ashtabula, Ohio

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrosilicon alloys	26,400
			Ferromanganese alloys	62,400

## Power

Since 1948 the plant has shifted from purchased power to plant generated steam power. Maximum 1 hour full-load demand is 46,000 kw. Power available is slightly more than continuous full load demand. Transformer capacity is sufficient and interchangeable between furnaces.

## Portland works

Portland, Oreg.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrosilicon alloys	13,200

## Power:

Hydro-electric power is purchased from the Columbia River Development. Maximum 1 hour full-load demand is 7,500 kw. Power is available for continuous full-load operation. Transformer capacity is sufficient and interchangeable between furnaces.

## Marietta plant

Marietta, Ohio

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
			Ferrosilicon alloys	36,200
			Ferromanganese alloys	76,800

### Power:

This plant is now under construction and is not expected to be in operation until the latter part of 1951. Maximum full-load 1 hour demand is anticipated at 50,000 kw. It is not known whether the power will be generated or purchased but it will, in all probability, be steam-generated.

## Keokuk Electro-metals Co.

429 South 5th St.  
Keokuk, Iowa

Keokuk plant  
Keokuk, Iowa

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phase</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	3,000	3	FeSi 15%-20%	10,220
2	6,000	3		32,700
3	4,000	3		16,350
4	4,000	3		16,350
5	6,000	3		32,700
6	6,000	3		32,700
7	6,000	3		32,700

### Power:

About 60 percent of the power is hydro-electric purchased, the other 40 percent being steam-generated in the plant. Maximum 1 hour full-load demand is 41,000 kw. Available power is about 95 percent of continuous full-load demand. Transformer capacity is presumed sufficient.

## Chester plant

Chester, Pa.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	200	1	TiAl (5%-2 1/2 %	2,160
2	1,200	1	Al shot-Al grain	10,800

### Power:

Power is purchased and steam generated. Maximum 1 hour full-load demand is 1,500 kw. Power available is about 84 percent of continuous full-load demand. Transformer capacity is presumably sufficient.

Molybdenum Corp. of America

Grant Building  
Pittsburgh 19, Pa.

Washington works  
Washington, Pa.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	333	1	Standard - Grade ferro-	
			tungsten	350
2	333	1	"	350
3	333	1	"	350
4	333	1	"	350
5	333	1	"	350
6	333	1	"	350
7	333	1	"	350
8	333	1	"	350
9	333	1	"	350
10	333	1	"	350
11	333	1	"	350

### Power:

Power is purchased from the West Pennsylvania Power Co., where it is steam-generated. Maximum full-load 1 hour demand is 3,800 kw. Power available is about 60 percent of continuous full-load demand. Transformer capacity is presumed sufficient.

National Lead Co.

Titanium Alloy Manufacture Division  
111 Broadway  
New York 6, N. Y.

Niagara Falls plant  
Niagara Falls, N. Y.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	750	1	Zirconium cyanonitride	480
2	750	1	do.	480
3	750	1	do.	480
4	750	1	do.	480
5	1,200	1	do.	560
6	1,200	1	Titanium cyanonitride	100
7	1,200	1	Ferrocabon titanium	1,460
8	1,200	1	do.	1,460
9	2,000	1	do.	2,200

Power:

Hydro-electric power is purchased from the Niagara Falls Electric Co. Maximum 1 hour full-load demand is 10,000 kw. Power is available for about 90 percent of continuous full-load demand. Transformer capacity is presumed sufficient.

Ohio Ferro-alloys Corp.

100 Citizens Bank Building  
Canton, Ohio

Philo plant  
Philo, Ohio

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grades</u>	<u>Capacity, tons</u>
1	9,000	3	Ferrosilicon, 25%, 50% <u>1/</u> 65%, 75%, 85%, 90%	14,600
2	7,000	3	Ferrosilicon, special blocking 50%	11,680
3	5,500	3	Low carbon ferrochrome silicon	8,020
4	6,000	3	High carbon ferrochrome	9,125
5	5,000	3	Ferromanganese	10,950
6	1,000	3	Borosil	1,825
7	7,000	3	Simanal	11,680

1/ 50 percent ferrosilicon.

Power:

Power is purchased and is presumably steam-generated. Maximum 1 hour full-load demand is 40,000 kw. Power available is about 95 percent of continuous full-load demand. Transformer capacity is presumed sufficient.

## Takoma plant

Takoma, Wash.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	6,000	3	High-carbon ferrochrome	9,125
2	6 000	3	do.	9,125

### Power:

Hydro-electric power is purchased. 1/ Maximum 1 hour full-load demand is 12,000 kw. Power is available for 100-percent continuous full-load demand. Transformer capacity is presumed sufficient.

1/ Actual full load would be higher, due to lighting, material-handling equipment, etc.

Pittsburgh Metallurgical Co.

3801 Highland Ave.  
Niagara Falls, N. Y.

Niagara Falls works  
Niagara falls N. Y.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>1/ Capacity, tons</u>
1	3,300	3	Ferrosilicon, 15%-95%	4,900
2	3,300	3	do.	4,900
3	3,300	3	do.	4,900
4	6,600	3	do.	10,080
5	3,700	3	do.	5,040
6	2,000	1	High-carbon ferrochrome	3,360
7	7,000	3	Ferrosilicon 15%-95%	12,320

1/ Capacity on 50-percent ferrosilicon.

Power:

Hydro-electric power is purchased from Niagara Falls Electric Co. Maximum 1 hour full-load demand is 27,500 kw. Power is available for about 90 percent continuous full-load capacity. Transformer capacity is presumed sufficient.

Charleston plant  
Charleston, S. C.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	2,000	1	High carbon ferrochrome	3,360
2	2,000	1	do.	3,360
3	2 000	1	do.	3,360
4	6,600	3	Ferrosilicon 15-90%	10,080
5	9,500	3	Low carbon chrome silicon	8,960
6	9,500	3	do.	8,960
7	9,500	3	Ferrosilicon 15-90%	10,080

Power:

Power is purchased. Maximum 1 hour full-load demand is 35,000 kw. Power is available for about 80 percent of continuous full-load demand. Transformer capacity is presumed sufficient.

One additional 3-phase furnace for the manufacture of low-and medium-carbon ferro-alloys is under construction and is to be in operation late in 1950.

Calvert City plant

Calvert City, Kentucky

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phase</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	3,000	1	High carbon ferrochrome	8,160
3	10,000	3	Ferrosilicon, 15-90%	15,680 (50%FeSi)
3	10,000	3	Low carbon chrome silicon	11,200
4	10,000	3	Ferrosilicon, 15-90%	15,680 (50%FeSi)

Power:

Power is purchased. Maximum 1 hour full-load demand is



31,000 kw. Available power is not definitely known but is assumed to be over 60 percent of continuous full-load demand. Transformer capacity is assumed sufficient.

Two additional furnaces are under construction, one single-phase furnace for high-carbon ferrochrome and one three-phase furnace for ferrosilicon or low-carbon ferrochrome silicon. These furnaces should be completed later in 1950 or early in 1951.

Tennessee Products & Chemical Corp.

American National Bank Building  
Nashville 3, Tenn.

Southern Ferro Alloy Division  
4800 Central Ave.  
Chattanooga, Tenn.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
AC	1,950	3	50% ferrosilicon	3,270
B	2,500	3	do.	4,490
D	3,600	3	do.	5,720
E	6,000	3	do.	8,175
F	6,000	3	do.	8,175
G	6,000	3	do.	8,175
H	6,000	3	do.	8,175
K	3,750	3	do.	5,780
L	3,600	3	do.	4,490

Power:

Hydro-electric power is purchased from TVA.

Vanadium Corp. of America

Niagara Falls plant  
Niagara Falls, N. Y.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1	6,000	3	50% ferrosilicon	10,000
2	6,000	3	75% ferrosilicon	5,000
3	7,500	3	Ferro-chromium silicon	6,800
4	7,500	3	do.	6,800
5	6,000	3	50% ferrosilicon	10,000
7	300	3	Ferrochromium processing- not a producing unit.	
8	3,000	1	4-6% carbon ferrochromium	5,000
9	3 000	1	do.	5,000
14	4,000	1	50% ferrosilicon	5,400
15	4,000	1	do.	5,400
16		1	No transformer available- not producing. Unit similar to No's. 14 and 15.	
17	3,000	1	Low-carbon ferrochromium	4 500
18	2,500	1	do.	4,500
19	2,500	1	do.	3,300
20	2,500	1	do.	3,300
21	2,000	1	do.	3,000
22	2,000	1	do.	3,000
23	1,200	1	High-carbon ferrotitanium	1,200
24		1	No transformer available- not producing. Unit similar to No's. 23 and 25.	700

17, 18, 19, 20, and 22 are single-phase, double-electrode furnaces.

Power:

Hydro-electric power is furnished by the Niagara Falls Electric Co. Maximum 1 hour full-load demand is 59,280 kw. Power available is about 88 percent of the continuous full-load demand. Transformer capacity is limited as shown.

# Bridgeville plant

Bridgeville, Pa.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
2	2,000	3	Ferrovanadium - all grades	2,500

## Power:

Power is purchased and steam generated. Maximum 1 hour full-load demand is 3,000 kw. Power is available to satisfy continuous full-load demand. Transformer capacity is presumed sufficient.

# Rock Island plant

Wenatchee, Wash.

<u>Fce</u>	<u>Kv. -a.</u>	<u>Phases</u>	<u>Product and grade</u>	<u>Capacity, tons</u>
1			22% FeSi-20,440	per furnace
			or	
2			75% FeSi- 6,140	
3	Contemplated			
4	do.			

## Power:

Unknown source, presumed to be hydro-electric. Two furnaces are in operation at the present time, and two furnaces are contemplated.





XXII. HISTORY - CONTROLS WORLD WAR I AND II



## CHAPTER XXII. WORLD WAR I & II

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## XXII WORLD WAR I & II

### A. GOVERNMENT, STATE, PROFESSIONAL, AND TRADE ACTIVITIES, APRIL 1917, - DECEMBER 1918

The entrance of the United States into the First World War marked the beginning of a number of activities in the manganese industry by existing and new government, state, trade, and professional organizations, all of which were planned to meet the unusual conditions in the industries created by the war.

In April 1917 the existing government organizations that were authorized and prepared to consider the problems of the mineral industries were the Geological Survey and the Bureau of Mines of the Department of the Interior, the Bureau of Foreign and Domestic Commerce of the Department of Commerce, and the Council of National Defense.

The Geological Survey, created in 1879, had made comprehensive studies of the mineral resources of the country and had collected and published annually and for some products monthly, comprehensive statistics concerning the production and shipments of many raw minerals as well as of some metals and manufactured products. The Geological Survey worked in close cooperation with many State Geological Surveys and therefore possessed or had access to a wealth of detail concerning mineral resources and the mineral industries.

In August 1914, soon after the outbreak of war in Europe, the Director of the Survey and his available assistants in Washington compiled a bulletin (1) which summarizes the sources of American supplies and indicated the degrees of our independence in minerals. This was followed in 1917 by more exhaustive pamphlets on each of the mineral commodities. (2) In April 1917, field studies of manganese deposits were begun, which attempted to determine the immediately available and the prospective reserves of each grade of manganese ore and the probable rate of production in the near future. These studies were gradually extended throughout all the States and, so far as possible, were made in cooperation with the existing State organizations. When the armistice was signed in November 1918, most of the known deposits had been examined. (3)

The Bureau of Mines, created in 1910, had made many studies of mining, milling, and metallurgic technique, as well as of safety devices and methods. After a preliminary field survey of the problems

of production and utilization of domestic manganese ores from May to August 1917, engineers were sent to most of the productive fields to aid in improving mining and milling practice and to smelting and steel works to determine methods for economical and efficient use of the ores and alloys. The results of these studies are recorded in a series of reports published during 1918 and 1919 under the general title "War Minerals Investigations."

The Bureau of Foreign and Domestic Commerce, created in 1912, has collected statistics concerning the source, quantity, and destination of imported and exported materials, raw as well as manufactured.

The Council of National Defense, established by act of Congress in August 1916, was charged with the "coordination of industries and resources for the national security and welfare" and with the "creation of relations which will render possible in time of need the immediate concentration and utilization of the resources of the Nation." It was composed of six Cabinet officers and an advisory commission of seven other persons, and by April 1917 many advisory committees had been appointed. Naturally, a number of these committees were drawn from officials of the principal companies engaged in production and manufacture and from trade organizations. Thus the committee on production of steel included officials of several steel companies, and the subcommittee on ferro-alloys was identical with a similar committee of the American Iron and Steel Institute.

In May 1917 the American Iron and Steel Institute, interested primarily in the steel and alloy trades on behalf of its members, began to collect and distribute to its constituents monthly reports on the receipts, consumption or sales, and stocks of manganese ore and ferromanganese. It planned to make a survey of the distribution of domestic deposits and the prospect for increased production, but in June it relinquished this inquiry to the Geological Survey. The inquiry showed that domestic mines were vigorously responding to the increased demand for high-grade ore and that there was a probability that the shipments for 1917 would be about 10 percent of total needs, in contrast to 1 percent or less in recent years. This was the first of the quarterly summaries and forecasts that were prepared by the Geological Survey until July 1919. Probably the most important result of this inquiry was the indication that new deposits were being found in many parts of the United States, especially in the Rocky Mountain region and on the Pacific coast, and that any forecast of shipments based entirely upon the trend of recent shipments would be very misleading and probably lower than the actual shipments.

An organization that was to play an important part in the manganese-ore industry and the legislation affecting it was formed in June, 1917. It was known as the War Minerals Committee and included W. Y. Westervelt, chairman, representing the American Institute of Mining Engineers and the Mining and Metallurgical Society of America; W. O. Hotchkiss, representing the Association of American State Geologists and the National Research Council; David White, representing the Federal Geological Survey; and A. G. White, representing the Bureau of Mines.

The committee met in Washington frequently during June, July, and August 1917 to study foreign and domestic mineral supplies, requirements, and possible substitutes, as well as the problems of transportation and uses. It made the first attempt to give widespread publicity to the relation between available ships and the maintenance of adequate supplies of essential minerals and related manufactured products. As the result of later meetings in November and December 1917 and January 1918, a bill was introduced into Congress that provided for giving comprehensive control of the supplies of most minerals to a mineral administrator, to be appointed by the President.

To make available to new and inexperienced operators of manganese deposits in Virginia a better class of engineering assistance than they could pay for, the committee arranged through the secretary of the American Institute of Mining Engineers and the Bureau of Mines to have a party of engineers visit the mines. It also attempted, particularly at the meeting of the American Institute of Mining Engineers in St. Louis in October 1917 to make it widely known among American mining engineers and geologists that there was great need for domestic supplies of certain raw minerals, especially manganese and chrome ores and pyrite.

Soon after the United States declared war on Germany, the committees of the Council of National Defense called for special reports on many industries. In May 1917 the Division of Raw Materials requested the Bureau of Foreign and Domestic Commerce to prepare statistical reports on the ferro-alloy ores, manganese, chromium, and tungsten, showing recent monthly imports and sources, quantity and destination of exports, and apparent consumption. In September 1917 it also requested the Geological Survey to prepare a report on the possibility of restricting imports of manganese ore in the near future. Having access to recent reports from geologists in the field and from the operators that indicated great increase in domestic production of all grades of ores, the Geological Survey was able to recommend the

program of imports for 1918 shown below. To permit a comparison, the actual imports for the year 1918 are shown also.

Table XXII-1. RECOMMENDED AND ACTUAL IMPORTS OF MANGANESE ORE INTO THE UNITED STATES IN 1918, IN TONS

<u>Country</u>	<u>Recommended</u>	<u>Actual</u>
Brazil	340,000	345,877
Cuba	50,000	82,974
Panama	5,000	5,607
Costa Rica	15,000	9,680
Others	None	47,165
	410,000	491,303
Ferromanganese	None.	27,168

The estimate made in 1917 was little more than a guess, and at the time few considered it sufficient to meet needs. Actually, it was not much less than the imports received under a program of import control made 6 months later. As the surplus stocks of manganese ore and alloys steadily increased from April until November, 1918, the 410,000 tons of imported material recommended by this program obviously would have been sufficient to meet needs and maintain stocks.

The event that had the most far-reaching effect in the manganese industry during the war was formation of the Mineral Imports and Exports Committee of the Shipping Board in January 1918 with C. K. Leith as chairman and J. E. Spurr as advisory member. By Executive order early in February 1918 the War Trade Board, which was created out of the Bureau of Export Licenses in June 1917, was authorized to use its licensing power to control imports. The Shipping Board, acting upon the advice of its committee, was thereby enabled to conserve shipping by restricting imports. Nitrate from Chile, pyrite from Spain, and manganese ore from Brazil and India made up a large part of the quantity of minerals imported, and the committee as led to suspect that substantial reductions might be made. In January the committee requested estimates of the probable production and necessary imports of manganese ore from several Federal and trade organizations as well as from informed individuals.

From September 1917 to January 1918, the advisory committees of the Council of National Defense ceased to exert a powerful influence

in the field of industry, and the War Industries Board, first as a part of and later independently of the Council of National Defense, with B. M. Baruch as chairman, was given broad powers under Executive order to organize the industries of the country to meet war needs. Thus, in planning to place a program of imports before the manganese industry, the Mineral Imports and Exports Committee, in cooperation with the War Industries Board, during March 1918, called meetings of the consumers of manganese ore, as represented by the Ferro-alloy Subcommittee of the American Iron and Steel Institute and the producers. After many conferences the following program of imports was recommended by the committee:

High-grade ore (more than 40 percent of manganese):	<u>Tons</u>
Domestic (estimated) .....	175,000
Cuba .....	100,000
Panama and Costa Rica .....	20,000
Brazil .....	<u>345,000</u>
	640,000
Lower-grade ore (15 to 40 percent of manganese, all domestic) .....	520,000
Zinc residuum (domestic) .....	175,000
Ferromanganese (to be imported) .....	None

This program was later modified slightly to permit importation of 12,000 tons of ferromanganese and enough manganese ore from Brazil to make up certain losses, such as that caused by disappearance of the steamship Cyclops, which carried 10,000 tons of manganese ore.

Meanwhile the prospect of a reduction in imports of manganese ore drew the attention of many members of the steel trade to substitutes and methods of conservation. Several plans were offered, but that which was finally urged upon the members of the American Iron and Steel Institute in a letter signed by its president early in April 1918 provided for reducing the grade of standard ferromanganese from 80 to 70 percent manganese and that of spiegeleisen from 20 to 16 percent manganese. In the announcement of the new grades, the members were urged to substitute available grades of domestic ore for the foreign ore recently used. The calling of a meeting of the metallurgists, chemists, and other technical members of the staffs of the steel companies at Pittsburgh, May 7, 1918, was more important, however, because it brought forcibly to the attention of those who were actually using the materials the serious nature of the problems of conserving

the supply of manganese ore and alloy.

The situation thus created led to adoption of several rather different plans by ore consumers. The greatly increased production of spiegeleisen during 1918 shows clearly that many steel companies must have substituted spiegeleisen for ferromanganese to a greater extent than many thought possible before. There was therefore a great increase in demand for low-grade ores, which the country was well prepared to produce. Other companies substituted 60-and 70-percent for 80-percent ferromanganese; and, in order to obtain the proper ratio of iron and manganese, used large quantities of manganese ores containing 15 to 30 percent manganese, which were smelted with the high-grade imported and domestic ore.

The importance of the ferro-alloy industries and the many and frequent readjustments that were taking place in them led to creation in March 1918 of a section of ferro-alloys in the War Industries Board, with H. W. Sanford as chairman. In June C. D. Tripp, a maker of ferromanganese, and in September C. M. Weld, mining engineer of the Bureau of Mines, were added to the section. In May 1918, the Mineral Imports and Exports Committee of the Shipping Board, having completed a program of imports for 1918 and submitted a report, was dissolved, and its chairman became mineral adviser to the chairman of the War Industries Board.

The shortage of many materials during the war and the advantage of prompt delivery produced extraordinary and rapid fluctuations in prices of materials. The price of ferromanganese rose rapidly during 1916 and 1917 to 10 times that in the first half of 1914, but the increases in price of ore lagged 6 to 8 months behind the price of the alloy. Although the advances in price of ore and alloy were about equal from December 1917 to March 1918, or six times the prices in 1913, there were many complaints from producers of ore that prices of ore should be higher. As in many other industries, these complaints led to trade agreements by which the prices of both ore and ferromanganese were practically fixed. On May 28, 1918, the War Industries Board announced that it had approved an agreement between the members of the American Iron and Steel Institute to pay the schedule of prices set forth on pages . Although no agreement concerning the price of ferromanganese was ever announced, the price did not fluctuate appreciably until late in December 1918, when it declined rapidly.

As noted elsewhere, the great increase in production of ore during 1917 and 1918 came from mines west of Colorado, where freight rates to points of consumption ranged from \$7.50 to \$15 a ton. When freight rates throughout the country were increased 25 percent in June 1918, many complaints were made by producers of ore that they would greatly curtail shipment of ores from western mines. After a conference of members of the Shipping and War Industries Boards, the Geological Survey, and the Bureau of Mines, the United States Railroad Administration was requested to consider a plan for reducing rates on manganese ore from Western States. In August new rates were announced on manganese ore from the Western States to the principal consuming centers in Illinois, Pennsylvania, and Alabama. The new rates from Pacific Coast States were slightly lower than those in effect before June 1918, but several rates on material from Colorado were slightly higher.

From June 1918, when the policy of restricting imports was beginning to be effective, to November, when the armistice was signed, no new agencies were created that affected trends in the manganese industry. The existing organizations, including the Shipping Board, the War Industries Board, the Bureau of Mines, and the Geological Survey, devoted their efforts largely to coordinating the work of collecting and, where desirable, disseminating information that would aid in meeting the program of reduced imports. Much space would be needed to give many of the details concerning this work. It included a wide range of activities, such as careful studies of the reserves of domestic ores of each grade, current and prospective rate of production, maintenance of skilled labor at mines as well as supplies and equipment, studies of mining and milling technique and costs, maintenance of car supply, readjustments of freight rates, encouragement of more efficient uses, and study of the problems of marketing.

No statement concerning the history of the domestic industry during 1917 and 1918 would be complete without a tribute to the energetic spirit of many prospectors, miners, and mine operators, through whose efforts the search for and exploitation of manganese deposits was carried throughout the United States. Many of these men were doubtless largely inspired by the prospect of financial success, and many were woefully ignorant of the risks of the ventures they undertook, but only a cynic could fail to recognize in many of them a sincere desire to use their specialized knowledge to make a contribution to the common cause of their country, even through the chances of the game financially were against them. A simple calculation will



show that, largely through their efforts during 1918 alone, the importation of about 180,000 tons of foreign manganese ore was avoided and consequently 50,000 tons of ship capacity was diverted to uses more directly related to winning the war.

## B. WAR MINERALS MEASURES IN 1917 AND 1918

The term "war minerals" was first used early in 1917 to include those minerals that were necessary or highly useful in the industries for a supply of which the United States had largely depended upon foreign sources and of which there was a shortage due to the shipping situation during the war. It does not include all minerals useful in the arts of war, for most minerals have extraordinary usefulness during a war among highly industrial nations. It was commonly meant to include the common minerals from which the following elements or their useful compounds were obtained: Antimony, arsenic, chromium, graphite, manganese, platinum, potassium, sulfur, tin, and tungsten. The term was first given prominence early in 1917 by the War Minerals Committee, previously mentioned.

It was widely known that the territory of the United States contained most of the raw materials needed for the industries of the country during war, such as coal, oil, iron ore, lumber, cotton, and wool. Although some persons believed that the known resources of several minerals were adequate either to meet a part of expected needs for a long period, or to meet them entirely for a shorter period, it was a difficult problem to determine how much could be produced in the near future and whether certain guaranties were not desirable to assure a greater production. There would be cause for apprehension concerning the supply if marine transportation were greatly reduced or if the United States were isolated. Only a few persons, including most engineers and members of related professional groups, appeared to appreciate fully the technical and financial problems of producing quickly the minerals of which important but undeveloped resources were known. The exploration and exploitation of most minerals demand considerable time and expenditure of money, and few competent persons will undertake to produce them without some assurance that the product can be marketed long enough or at prices high enough to assure return of the capital. Prices of many minerals had risen since 1915, but it was widely suspected that, when foreign supplies could be obtained, prices would rapidly decline to those that prevailed before the war, and that this would probably be possible within a few months after the end of the war. During the summer of 1917 many persons came to believe that, rather than expecting private individuals to make the necessary investments to bring forth the greatly increased production

of many war minerals that were desired, the Government itself should practically assume control of the industries and buy, sell, and make contracts for the purchase and sale of the ores and some of the products made from them. It was claimed that there was good reason to expect that much larger shipments would be made if mine operators were assured markets for at least 2 years in advance than if future prices were left subject to the fluctuations of passing demand and the possibility of early ending of the war.

Interest in the matter finally led to the preparation of a bill by the War Minerals Committee; after conferences with many of the minerals producers, this bill was introduced into Congress in January 1918. The bill provided for wide powers over the production and distribution of many minerals and metals by a system of licensing. It provided for the establishment of maximum and minimum prices and, under necessity, for the actual operation of mines and reduction plants by the Government. After hearings before the Committee on Mines and Mining of the House of Representatives during March and April, the bill was greatly revised and finally passed by that body. The new bill (H. R. 11259, 65th Cong., 2d sess.) provided for control over fewer minerals and metals and placed its administration in the hands of the Secretary of the Interior.

Hearings on the new bill were held by the Committee on Mines and Mining of the Senate during May. Some opposition to the plan to control any of the mineral industries had been developed during the hearings in March, but formidable opposition was developed in May, particularly among the consumers of ferro-alloys. This opposition and other causes led to delay in reporting the bill out of the committee. The bill that was finally passed (No. 220, 65th Cong.) and signed by the President October 5, 1918, provided that "by reason of the existence of a state of war, it is essential to the national security and defense and to the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to provide for an adequate and increased supply, to facilitate the production and to provide for an equitable, economical, and better distribution of the following-named mineral substances \* \* \* as the President may from time to time determine to be necessary for the purposes aforesaid and as to which there is at the time of such determination a present or prospective inadequacy of supply." In order to use the powers of the act it was obviously necessary to determine the "present or prospective inadequacy of supply." In respect to manganese ore, domestic production had steadily increased to the maximum of 90,738 tons during the third quarter of 1918, or at a rate that slightly exceeded the estimate made in March; and imports, particularly from India, were

also larger than early estimates. These factors, taken with economies in the use of ore and alloys, led to an increase of stocks, so that 9 months' supply was available on the basis of the current rate of production of steel. When the armistice was signed, in November 1918, contracts for steel were widely canceled, and the consumers of manganese ores ceased to purchase ores. Many mine operators urged that the "war minerals act" be used to protect the domestic ore industry by replacing a tariff on imports, which continued to enter the country from remote sources. As there was no "present or prospective inadequacy of supply," the act could not be so used.

Until October 1918 the country looked forward to at least another year of war. Naturally many manganese mine operators found themselves in November with large as well as small investments in mines that were made in anticipation of a longer war. Such operations, with those of mines of other war minerals, especially chrome, pyrite, and tungsten, made strong appeals for aid, many claiming that they had been urgently requested by members of the War Industries and Shipping boards, as well as by the Bureau of Mines and the Geological Survey, to enter into or increase the production of the "war minerals."

These appeals were finally recognized by Congress by the passage of the war contracts act (Rept. 1144, 65th Cong., 3d sess.), which provided that "the Secretary of the Interior be, and he hereby is, authorized to adjust, liquidate, and pay such net losses as have been suffered by any person, firm, or corporation, by reason of producing or preparing to produce, either manganese, chrome, pyrites, or tungsten in compliance with the request or demand of the Department of the Interior, the War Industries Board, the War Trade Board, the Shipping Board, or the Emergency Fleet Corporation to supply the urgent needs of the Nation in the prosecution of the war." \$8,500,000 was appropriated to pay such claims and defray the expenses of administration.

Acting under the authority of the act, the Secretary of the Interior has appointed a commission of three to administer it.

### C. VALUE OF MANGANESE ORES

In general, the value of materials that contain manganese depends on the composition, the minerals present, and the condition or state of aggregation of the material. The value depends largely, of course, on the content of metallic manganese, but incidentally on the absence of such substances as phosphorus, silica, copper, cobalt, and iron. For certain purposes other things being equal, it depends on

the amount of oxygen that will be liberated under certain conditions, and this is different for the several oxidized minerals. If manganese alloys are to be produced in the blast furnace, the material should be in coherent lumps, as fine sand and powder can not be treated to advantage. On the other hand, if the material is to be used to make dry batteries or flint glass and is not already in finely divided condition it is crushed and pulverized.

The year 1917 was marked by an extraordinary increase in the price of both manganese alloys and ore and a great increase also in the number of makers of the alloys, whose competition for ores was largely the cause of the increase in price. Several new makers of alloys appeared in the field during 1918; but several withdrew, so that the number remained only slightly larger than in 1917. Although the price offered for 45-percent Brazilian ore is reported to have risen to \$1.35 per unit of manganese, or \$60.75 per ton, during the first 3 months of 1918, there is no record that more than \$1.20 per unit was offered for any grade of domestic ore adapted to making ferromanganese earlier than May 15, 1918. The Carnegie Steel Co. issued no more schedules of ore prices after that of May 2, 1917.

The winter of 1917-18 witnessed gradual increase in power over most of the industries and the centralization of authority of the War Industries Board. To meet widespread complaint from ore producers concerning prices offered for ore, the board gave much attention to the manganese industry during March, April, and May 1918 and on May 28 announced that it had approved a new schedule of ore prices adopted by the ferro-alloys committee of the American Iron and Steel Institute. A copy of the announcement follows:

Schedule of Manganese-Ore Prices Effective May 28, 1918, Adopted  
by Ferro-alloys Committee of the American Iron and Steel Institute  
and Approved by the War Industries Board

Schedule for domestic metallurgical manganese ore prices  
unit of metallic manganese per ton of 2,240 pounds for manganese ore produced and shipped from all points in the United States west of South Chicago, Ill. This schedule does not include chemical ores as used for dry batteries, etc.

Following prices are on the basis of delivery f.o.b. cars, South Chicago, and are on the basis of all-rail shipments. When shipped to other destination than Chicago, the freight rate per gross ton from shipping point to South Chicago, Ill., is to be deducted

to give the price f. o. b. shipping point.

For ore containing metallic manganese when dried at 212° F.

	<u>Price per unit</u>
35 percent to 35.99 percent .....	\$0.86
36 percent to 36.99 percent .....	.90
37 percent to 37.99 percent .....	.94
38 percent to 38.99 percent .....	.98
39 percent to 39.99 percent .....	1.00
40 percent to 40.99 percent .....	1.02
41 percent to 41.99 percent .....	1.04
42 percent to 42.99 percent .....	1.06
43 percent to 43.99 percent .....	1.08
44 percent to 44.99 percent .....	1.10
45 percent to 45.99 percent .....	1.12
46 percent to 46.99 percent .....	1.14
47 percent to 47.99 percent .....	1.16
48 percent to 48.99 percent .....	1.18
49 percent to 49.99 percent .....	1.20
50 percent to 50.99 percent .....	1.22
51 percent to 51.99 percent .....	1.24
52 percent to 52.99 percent .....	1.26
53 percent to 53.99 percent .....	1.28
54 percent or more .....	1.30

For manganese ore produced in the United States and shipped from points in the United States east of South Chicago, 15 cents per unit of metallic manganese per ton shall be added to above unit prices.

Above prices are based on ore containing not more than 8 percent silica and not more than 0.25 percent phosphorus, and are subject to:

Silica premiums and penalties. - For each 1 percent of silica under 8 percent down to and including 5 percent, premium at rate of 50 cents per ton. Below 5 percent silica, premium at rate of \$1 per ton for each 1 percent.

For each 1 percent in excess of 8 percent and up to and including 15 percent silica, there shall be a penalty of 50 cents per ton; 15 percent and up to and including 20 percent silica, there shall be a penalty of 75 cents per ton.

For ore containing in excess of 20 percent silica, a limited tonnage can be used; but for each 1 percent of silica in excess of 20 percent, and up to and including 25 percent silica, there shall be a penalty of \$1 per ton.

Ore containing over 25 percent silica subject to acceptance or refusal at buyer's option, but if accepted shall be paid for at the above schedule with the penalty of \$1 per ton for each extra unit of silica.

All premiums and penalties figures to fractions.

Phosphorus penalty. - For each 0.01 percent in excess of 0.25 percent phosphorus there shall be a penalty against unit price paid for manganese of one-half cent per unit figures to fractions.

In view of existing conditions, and for the purpose of stimulating production of domestic manganese ores, there will be no penalty for phosphorus so long as the ore shipped can be used to advantage by the buyer. The buyer reserves the right to penalize excess phosphorus as above by giving 60 days' notice to the shipper.

The above prices to be net to the producer; any expenses, such as salary or commission to buyer's agent, to be paid by the buyer.

Settlements to be based on analysis of ore sample dried at 212° F. The percentage of moisture in ore samples as taken to be deducted from the weight.

Payments. - 80 percent of the estimated value of the ore (less moisture and freight from shipping point) based on actual railroad scale weights to be payable against railroad bill lading with attached certificates of sampling and analysis of an approved independent sampling chemist. Balance on receipt of ore by buyer.

Actual railroad scale weights to govern in final settlement.

Cost of sampling and analysis to be equally divided between buyer and seller.

According to this schedule, the price offered for 50-percent ore originating west of Chicago was \$61 per ton f. o. b. Chicago. If the ore originated east of Chicago the price was \$68.50 per ton f. o. b. Chicago. The schedule represented a slight advance in price of most ores with less than 10 percent of silica and was greatest for the ores originating in districts east of Chicago. As a large part of the domestic product, especially that from the Philipsburg district, Mont., and from California and Nevada contained more than 10 percent of silica, this silica caused widespread complaint from ore producers. In defense of the silica penalties, it should be stated that, as long as Brazilian ore with from 3 to 6 percent silica was freely available, a large quantity (possibly one-fourth of the total) of material with 15 to 18 percent silica could be smelted without causing serious losses. Under the program of restricted imports from Brazil adopted in May, however, a great increase in the percent of domestic ore would be certain to cause extraordinary smelting losses. The schedule remained in effect until January 1, 1919, but there is no record that any ores were purchased on the basis of it after November 11, 1918.

The value of an ore adapted to use as an oxidizer in dry batteries and flint glass varies with its content of manganese dioxide and in contradistinction to those used in metallurgical industries does not depend, except indirectly, on its content of metallic manganese. As much of the ore of the Caucasus region contains 85 to 92 percent of manganese dioxide and less than 1 percent iron and is therefore admirably adapted to these uses, most specifications for ores to be put to these uses before the war were such as could be met by ore from the Caucasus region but only rarely by ores from other regions. According to one manufacturer of dry batteries, as long as Caucasian ore was available there was little experimentation to determine the suitability of the several manganese minerals and the limits beyond which other elements than manganese may be present. As a result of recent experiments, it has been shown that copper, nickel, and cobalt are the most harmful elements in the ordinary dry battery and should not be present in even minute quantities. A few tenths of 1 percent of any of these elements renders an ore unfit for this use. On the other hand, it is stated that more than 2 or 3 percent of iron as oxide does not necessarily greatly affect the efficiency of a battery

and that the 1 percent limit is arbitrary. In the absence of an established schedule, such as that in the steel industry, most of the ore is supplied to the dry-battery makers by brokers in lots ranging from 5 to 100 tons under guaranteed specifications. On account of the temporary elimination of Caucasian ore, prices have risen, and it is reported that during 1918 prices ranged from \$80 to \$140 a ton. Few of the known deposits of the United States are capable of producing more than a small quantity of ore that contains less than 1 percent iron and a trace of copper, nickel, and cobalt. During 1918 considerable ore containing no more than 70 percent of manganese dioxide was marketed for these uses. It is estimated that the present demand for manganese ore for dry batteries and flint glass is about 35,000 tons a year.

The value of ferruginous manganese ores, manganiferous iron ores, and manganiferous silver ores depends on local conditions in the metallurgic industries that consume them, as the manganese content is used only indirectly. In both Minnesota and Colorado it is customary to pay a flat rate for ore having a certain percentage of manganese, iron, silica, moisture, and phosphorus. For each additional percent of manganese a premium is paid, and for each additional percent of silica or moisture a penalty is charged.

Ferruginous manganese ores containing 15 to 35 percent manganese, less than 15 percent silica, and the remainder chiefly iron were sold at the mines in 1918 at prices that ranged from \$4.50 to \$16 a ton.

Manganiferous zinc residuum is rarely sold in the open market but is smelted to spiegeleisen by the only company that produces it.

#### D. WORLD WAR II STRATEGIC ASPECTS OF MANGANESE

Manganese is one of the most vital strategic metals as far as this country is concerned because about 12.5 pounds are needed to desulfurize and deoxidize every short ton of steel, because 97 percent of the present supply must be imported (fig. 1) and because substitution would be extremely difficult. Only high-grade ore (48 percent or more Mn) is generally used in the manufacture of standard "ferro" grades, the form in which manganese is usually added in steel manufacture, so only high-grade ore is considered strategic. Although there are large quantities of low-grade manganese ore in the United States, domestic supplies of high-grade ore are small because few such deposits exist



and because the capacity of plants to beneficiate the low-grade ores remains insignificant.

The strategic aspects of manganese in the national defense program are under the constant surveillance of R. C. Allen, consultant, ferrous minerals and alloys, Office of Production Management, but priorities on manganese ores or alloys were not instituted during 1940. Acting in an advisory capacity is the Technologic Committee on Manganese of the National Academy of Sciences and the National Research Council, an organization appointed on July 25, 1940, to review projects for developing new processes for recovery of manganese from low-grade domestic ores and to study conservation of manganese for the Office of Production Management. The committee is composed of nine eminent scientists and engineers from Government and industry. During 1940, the committee issued two reports (4) showing how ferromanganese requirements in the United States during an emergency period could be reduced at least 40 percent. An abstract of these reports follows:

Under emergency conditions spiegeleisen could be substituted for at least 20 percent of the required ferromanganese. This substitution could be facilitated and even further extended by the manufacture of spiegeleisen with a higher manganese content than the usual 20 percent Mn, and this could be done using domestic ores. Another 20-percent saving in ferromanganese requirements could be obtained by following these practices:

(A) Where the maximum permissible content of phosphorus could be raised, a greater proportion of basic open-hearth slag could be returned to the blast furnace.

(B) The slag volume in the open-hearth furnace could be lowered by decreasing the silicon content of the pig iron and keeping silica from other sources to a minimum.

(C) Ladle additions of manganese rather than furnace additions should be used to the fullest practicable extent. Use of a preliminary leoxidizing addition (such as 10 to 15 percent ferrosilicon) is recommended where feasible.

(D) Equivalent physical properties may be obtained by substituting other (more expensive) metals for manganese in many of the higher-manganese steels.

Government Stockpile. - The Strategic Materials Act (Public,

No. 117, 76th Cong., 1st sess., ch. 190), which was signed by the President June 7, 1939, authorized the expenditure of \$100,000,000 over a 4-year period for the purchase of strategic materials. Of all strategic mineral commodities, manganese ore is required in the largest quantities. Two agencies of the United States Government -- the Metals Reserve Company (subsidiary of the Reconstruction Finance Corporation) and the Procurement Division of the Treasury Department-- signed contracts with domestic producers and with importers for the delivery of ferro-grade manganese ore to Government stockpiles over a period of years.

One of the largest contracts was with the Anaconda Copper Mining Co., Butte, Mont., which was to supply 80,000 long tons of nodulized rhodochrosite ore containing at least 55 percent Mn annually for 3 years. The ore was to come from the Emma mine and adjacent property in Butte and was treated at a plant finished in May 1941. The Cuban purchases were also particularly significant because delivery was virtually assured in contrast to the uncertainty attached to shipments from other overseas sources.

Government Purchases. - The following schedule regarding Government purchases of manganese ore, effective May 4, 1942, was published by the Metals Reserve Company. The terms are subject to change without notice and do not apply to ores originating outside the limits of the continental United States.

1. Quantity: One thousand (1,000) to ten thousand (10,000) long tons per contract. Contracts in excess of 10,000 tons may be obtained as a result of individual negotiations, provided reliable and complete engineering data submitted by the applicant warrant a contract for a larger quantity.

2. Term of contract: Deliveries must be completed within eighteen (18) months of the date of contract. If delivery of twenty percent (20%) of the tonnage contracted for has not been made within 6 months of date of contract, Buyer may cancel contract forthwith.

3. Quality: Purchases of domestic manganese ores are of three grades with the following specifications: \*

(a) Black oxide ores: The schedule of prices and the terms and conditions herein refer to black oxide ores of manganese.

(b) Concentrates: Manganese concentrates to be

acceptable under this schedule must be nodulized or sintered.

(c) Carbonate ores: Manganese carbonate ores will be accepted under this schedule only if calcined.

Table XXII-2. MANGANESE CARBONATE ORES

		"High Grade"	"Low Grade A"	"Low Grade B"
Manganese	Minimum	48.0 %	44.0 %	40.0 % *
Alumina	Maximum	6.0 %	10.0 %	No maximum
Iron	do.	7.0 %	10.0 %	do.
Phosphorus	do.	.18%	.30%	0.50%
Silica	do.	10.0 %	15.0 %	No maximum
Zinc	do.	1.0 %	1.0 %	1.0%

\* Under "Low-Grade B," manganese ore will be accepted to 35.0% minimum under penalties hereinafter prescribed.

Size of ore: None in excess of 12 inches and not more than 25% to pass a 20-mesh screen.

Buyer may reject any shipment which does not conform to the applicable requirements and specifications as set forth above.

4. Price: Effective May 4, 1942, contracts will be considered on the following schedule for domestic ores, within continental United States (excluding Alaska); all prices per long ton (2,240 pounds) of dry weight, f. o. b. cars at stock pile designated by Buyer.

"High-Grade" -- Base price, \$48.00 per long dry ton for ore containing 48.0% manganese with an increase of one dollar (\$1.00) per ton for each unit (22.4 pounds) in excess of 48.0%; fractions prorated. "High-Grade" ore containing not less than 48.0% manganese but otherwise falling below specifications but within the limits herein-after set forth will be accepted subject to the following penalties:

Iron --- Up to 10.0% maximum with a penalty of 1 ¢ per unit for each percent in excess of 7.0%; fractions prorated;

Silica --- Up to 15.0% maximum with a penalty of

1 ¢ per unit for each percent in excess of 10.0%;  
fractions prorated:

Alumina --- Up to 10.0% maximum with a penalty of  
1 ¢ per unit for each percent in excess of 6.0%;  
fractions prorated:

Phosphorus --- Up to 0.30% maximum with a penalty  
of 1 ¢ per unit for each 0.03% in excess of 0.18%;  
fractions prorated.

"Low-Grade A" --- Base price 35.25 per long dry ton  
for ore containing 44.0% manganese with an increase of eighty cents  
(\$0.80) per ton for each unit (22.4 pounds) in excess of 44.0%;  
fractions prorated.

"Low-Grade B" --- Base price \$26.00 per long dry ton  
for ore containing 40.0% manganese with an increase of sixty-five  
cents (\$.65) per ton for each unit (22.4 pounds) in excess of 40.0%;  
fractions prorated. Ore containing a minimum of 35.0% manganese  
will be accepted under this schedule with a penalty of \$1.30 per ton  
for each unit (22.4 pounds) less than 40.0%; fractions prorated.

In addition to the above prices, an allowance will be made  
for each long ton shipped equal to the freight tariff per long ton from  
Seller's nearest convenient rail station to Buyer's stockpile.

The cost of sampling and analysis by the Buyer, weighing,  
and unloading onto stockpile will be for the account of Buyer.

Under the contract, each lot will be priced under the  
grade within which the specifications fall. Thus a lot carrying 45%  
manganese but also 0.50% phosphorus would be priced as "Low-Grade  
B".

5. Shipment and Delivery: Seller will give such advice  
regarding shipment and arrival as Buyer may require at least 10 days  
prior to shipment of the ore from point of loading onto railroad cars;  
otherwise, any demurrage at the stockpile will be for Seller's  
account.

Shipment will be made in flat-bottom gondolas, if available,  
in lots of not less than one carload, to the stockpile designated by

Buyer. Seller will prepay the freight to such stockpile where the ore will be weighed in cars, light and loaded, on tract scales, and sampled for moisture. The lot will be sampled as unloaded and upon receipt of analysis, Buyer will advise Seller as to whether the ore is acceptable and under what classification.

If the lot is ascertained to be unacceptable under the above specifications, Seller will not be entitled to any allowance for prepaid freight and will be held responsible for the removal of this shipment of ore from the stockpile location. Upon failure so to remove the ore within fifteen days of due notice, Buyer may at its absolute discretion, remove such ore and the cost of such removal shall be for Seller's account; or Buyer may, at its option, otherwise dispose of such ore without any liability therefor. In the event that Seller fails to repay Buyer for the cost of removal within fifteen days after notice, Buyer may cancel the contract forthwith.

6. Payment: As soon as moisture and analysis determinations are received, Buyer will promptly pay Seller in accordance with the weight certificate and the above schedule.

7. Weights: The weight paid for will be net railroad tract scale weights (weight of loaded car less weight of empty car), less moisture as determined by standard practice.

8. Sampling and Analysis: Each lot will be sampled at the time of unloading, onto stock pile by a sampler designated by Buyer, three samples being taken, one for each Seller, Buyer, and Umpire, and analysis made for manganese and other guaranteed elements. Usual provisions will be made for splitting limits and settlement by average of Seller's and Buyer's analyses, or by trade practice if samples are sent to Umpire. Moisture samples will be taken in accordance with standard practice. Seller may have representative at sampling at his own expense.

9. Application for Contract: Forms may be obtained upon request from the Metals Reserve Company, 811 Vermont Avenue, N. W. Washington, D. C. All the information called for on the application form must be supplied before consideration can be given to granting a contract.

## E. PRICES

Prices of manganese ore (except battery ore) are upon a unit basis, the unit being 1 percent of a long ton (22.4 pounds) of contained manganese. Prices of battery-grade ore are quoted upon a per-ton basis, with a minimum requirement of manganese dioxide.

Ferromanganese. -- Standard ferromanganese containing 75 to 85 percent manganese was placed under formal price regulations May 1, 1942. A price of \$135.00 per long ton (\$120.50 per short ton) f.o.b. Atlantic Seaboard, except for two Southern producers for whom the price is established on an f.o.b. furnace basis, was made effective in this order. This price represented an increase of \$15.00 per long ton over the price which had prevailed since October 1-15, 1941. Other than manganese, standard ferromanganese was defined as metal containing a maximum of 1.25 percent silicon, 0.50 percent phosphorus, 7.50 carbon, and 0.05 percent sulfur. The maximum prices by grades were established as follows:

Kind of grade:	Maximum price per long ton
Containing 78-82 percent manganese	\$135.00
Containing less than 78 percent manganese but not less than 75 percent.	\$135.00 less \$1.70 for each 1 percent of manganese below 78 percent.
Containing more than 82 percent manganese but not more than 85 percent.	\$135.00 plus \$1.70 for each 1 percent of manganese excess of 82 percent.

Manganese Ore. -- Maximum Price Regulation 248 was released October 27, 1942 (effective November 9, 1942), fixing the price of manganese ore except battery and chemical ore at the following pig-ton unit rates:

cents f.o.b. railroad cars Mobile and New Orleans.

cents f.o.b. railroad cars Norfolk, Baltimore, Philadelphia, and New York.

cents f.o.b. railroad cars Fontana, Calif.; Pueblo, Colo.; and Provo, Utah.

These prices are for metallurgical ore of a base analysis of manganese 48 percent, iron 6 percent, silica plus alumina 11 percent, and phosphorus not over 0.18 percent upon a dry basis. Premiums and penalties due to variation of analysis are as follows:

#### F. PREMIUMS

Manganese content above 48 percent: 1/2 cent for each 1 percent.  
Iron Content below 6 percent: 1/2 cent for each 1 percent.  
Silica plus alumina content below 11 percent: Nothing.  
Phosphorus below 0.18 percent: Nothing.

#### G. PENALTIES

Manganese content:

Below 48 percent: 1 cent for each 1 percent down to and including 44 percent.

Below 44 percent: 4 cents, plus 1-1/2 cents for each 1 percent down to and including 40 percent.

Below 40 percent: 10 cents, plus 2 cents for each 1 percent down to and including 35 percent.

Iron content:

Above 6 percent: 1 cent for each 1 percent up to and including 8 percent.

Above 8 percent: 2 cents, plus 3/4 cents for each 1 percent.

Silica plus alumina content:

Above 11 percent: 1 cent for each 1 percent up to and including 15 percent.

Above 15 percent: 4 cents plus 3/4 cent for each 1 percent.

Phosphorus content:

Above 0.18 percent: 1/3 cent for each 0.01 percent.

The above premiums and penalties are applied pro rata to variations of a fraction of 1 percent.

Amendment 1 to Price Regulation 248 was issued November 30, 1942 (effective December 1, 1942), exempting metallurgical manganese ore with a manganese content of 40 percent or less. Previously ore of 35 percent or less manganese content was exempt.

The average mine value reported for ore containing 35 percent or more manganese during 1942 was about 72 cents per long-ton unit. Quotations on imported ore in the following table are from Engineering and Mining Journal. A duty of one-half cent per pound of contained

manganese is imposed on all imported manganese ore except that from Cuba and Philippine Islands, which enters duty free.

Table XXII- 3. DOMESTIC PRICES OF IMPORTED METALLURGICAL MANGANESE ORE IN 1942, IN CENTS PER LONG-TON UNIT

(C.i.f. North Atlantic ports, cargo lots, exclusive of duty)

	Begin- ning of year		Begin- ning of year	End of year
Brazilian, 46-48 percent Mn	\$0.630	Cuban (not dutiable):		
Chilean, 47-48 percent Mn	.650	50-52 percent Mn	\$0.780	\$0.915
South African, 50-52 per- cent Mn	<u>1/</u>	45-47 percent Mn	<u>1/</u>	.900

1/ Not quoted.

According to Engineering and Mining Journal, prices for chemical ores per long ton in carlots at the end of 1942 were as follows: Domestic, containing 70 to 72 percent MnO<sub>2</sub>, \$45 to \$50; Brazilian or Cuban, 80 percent, \$55; Javan or Caucasian, 85 percent, \$70 to \$75.

Price Regulation. -- The ceiling prices of manganese ore were virtually unchanged from 1942. Two additional minor amendments to Maximum Price Regulation 248 were issued in 1943. Amendment 2, effective February 15, 1943, exempted from price control any ore sold to a processor who uses it in the production of spiegeleisen or of ferromanganese containing less than 75 percent manganese, or who charges it directly in the production of steel or in foundry operations. Amendment 3 clarified the term "basing point" to mean that point which would result in the lowest cost for the buyer. Both amendments affected very small portions of the total manganese ore.

Revised Maximum Price Regulation 138, covering ferromanganese, manganese alloys, and metal, became effective July 1, 1943. This revision incorporated into the order all types of manganese alloying materials, whereas the original maximum price regulation covered only standard ferromanganese. The revised regulation (besides providing dollars-and-cents ceilings for standard ferromanganese, with specific differentials to cover crushing and grinding) established specific maximum prices for spiegeleisen, silicomanganese, manganese metal, and substandard ferromanganese, previously covered by the



general maximum price regulation. The prices provided in the new revised regulation were essentially the same as those previously in effect. An exception was a small increase made to cover the expenses of freight and handling of the two smallest sizes of standard ferromanganese. Minor revisions to this regulation were published in Amendment 1 to Revised Maximum Price Regulation 138, effective August 7, 1943.

Earlier regulations issued by the Office of Price Administration are described in the Manganese and Manganiferous Ores chapter of Minerals Yearbook, 1942.

#### H. MANGANESE AND MANGANIFEROUS ORES AND GENERAL CONDITIONS

In considering the future of the domestic industry the reserves of the country must be divided into three classes irrespective of quantity: (a) High-grade chemical ore, (b) high-grade ore and ore capable of beneficiation, and (3) low-grade ferruginous or manganiferous ores.

Aside from any effect of tariff legislation, the future of the ore of the first class is apparently rather bright, as its grade and character and the cost of production probably will permit it to be sold in competition with most foreign ore in the domestic chemical market. Its most dangerous competitor is the Russian ore, which apparently is not yet available in large quantities in the United States market.

Most of the ore of the second class cannot be mined at a profit under normal conditions in open competition with imported ore. This normal disadvantage, due to grade and cost, has been intensified by the acquisition of high-grade foreign deposits by American capital, particularly by steel producers, who are thus assured of an adequate supply of high-grade ore, the present cost of which will probably be reduced by the adoption of more efficient methods of mining and transportation.

The ore of the third class includes two varieties that should find a domestic market, regardless of tariff or foreign competition - the manganiferous ore used for flux by the copper, silver, and lead smelters of the West and the ferruginous manganese and manganiferous iron ore used in the manufacture of high-manganese pig iron.

## Prices

Ceiling prices on foreign ore in effect at the close of 1942 continued throughout 1943. However, the Metals Reserve Company, which is exempt from maximum price regulations, issued a new purchasing schedule (5) which increased substantially the prices paid for certain domestic ores. Thirty-five-percent ore formerly purchased by the Metals Reserve Company at \$19.50 per long dry ton (disregarding penalties) was increased in price to \$28.00 per ton. This schedule was designed to increase the price paid by the Metals Reserve Company for ores containing just over 35 percent manganese and at the same time to maintain the previous price of \$1.00 per long-ton unit (48.00 per long dry ton) for standard 48-percent ore. This action did much to aid small producers of marginal ore.

The average mine value reported for ore containing 35 percent or more manganese during 1943 was 73 cents per long-ton unit compared with 72 cents in 1942. Quotations on imported ore in the following table are from Engineering and Mining Journal. A duty of one-half cent per pound of contained manganese is imposed on all imported manganese ore except that from Cuba and the Philippine Islands, which enters duty free.

Table XXII-4. DOMESTIC PRICES OF IMPORTED METALLURGICAL MANGANESE ORE IN 1943, IN CENTS PER LONG-TON UNIT

(C.i.f. North Atlantic ports, cargo lots, exclusive of duty)

	Begin- ning of	End of year		Begin- ning of year	End of year
Brazilian, 48 percent Mn	\$0.788	\$0.788	Cuban (not dutiable) 48 percent Mn	\$0.900	\$0.900
Chilean, 48 percent Mn	.788	.788	Indian:		
South African, 48 percent Mn	.788	.788	50 percent Mn	.798	.798
			48 percent Mn	.788	.788
Cuban (not dutiable): 51 percent Mn	.915	.915			

According to Engineering and Mining Journal, prices for chemical ores per long ton in carlots at the end of 1943 were as follows: Brazilian, 80 percent MnO<sub>2</sub> minimum, \$55.00; Javan or Caucasian, 85 percent minimum, \$70 to \$75; domestic, 70 to 72 percent, \$45 to

\$50 f.o.b. mines.

Government purchases continued at a high rate during 1944. On September 1, 1944, the Metals Reserve Company issued new regulations to affect all contract and small-lot purchases of domestic manganese ore made after December 31, 1944. The specifications were relatively severe and forced the closing of shippers that depended on the Government to purchase their product. Although the new schedule is more severe with regard to specifications, the prices for certain grades of ore are considerably higher than previously. For example, the base price for 42-percent ore under the new schedule is \$39.06 per long dry ton compared with \$27.30 under the terms of the previous schedule effective since May 4, 1942. However, the rate for 48-percent ore is unchanged at \$1 per unit or \$48 per ton. The price regulations affecting purchases of small lots of manganese ore are identical to the contract specifications except that concentrates are acceptable only on a negotiated basis.

A brief comparison in the prices (disregarding penalties) under the old and new schedules follows. Penalties that are more severe than before will lessen to some extent the advantage of a higher basic rate.

Table XXI-5. METALS RESERVE COMPANY PRICES FOR DOMESTIC MANGANESE ORE UNDER 1945 SCHEDULE COMPARED WITH SCHEDULE EFFECTIVE FROM 1942 TO 1945

Grade (percent Mn dry)	Price per long dry ton		Grade (percent Mn dry)	Price per long dry ton	
	Old	New		Old	New
4	\$54.00	\$55.62	46	\$36.80	\$45.08
12	52.00	53.04	44	35.20	42.24
50	50.00	50.50	42	27.30	39.06
48	48.00	48.00			

Price regulation. -- Ceiling prices for manganese ore remained unchanged at 90 cents per long-ton unit at New York, Philadelphia, Baltimore, Norfolk; 85 cents at Mobile and New Orleans; and 96 cents at Fontana, Calif.; Provo, Utah; and Pueblo, Colo.

Regulation 248 prescribes maximum prices for metallurgical manganese ores. Amendment 4 to the regulation was issued April 10, 1944, exemption deliveries of manganese ore in quantities not exceeding 500 pounds. The amendment was issued to cover small quantities of ore shipped for experimental purposes by educational and private laboratories and industries.

New operations. -- Domestic production of manganese ore was bolstered by three new operations that contributed 46,183 short tons of concentrates and nodules during 1944. A brief discussion of these operations follows:

The leaching and nodulizing plant of the Manganese Ore Co., Las Vegas, Nev., closed on September 30, 1944, after producing 13,963 tons of nodules since operations were begun in October 1943. Slightly over 500 men were released at the close of operations, and a very few stayed on to study the process further. This plant, which was designed to produce 100,000 tons of nodules annually, failed to reach anything near capacity. The operation was marked by a series of mechanical failures and problems, many of which might have been obviated through experimentation with a pilot plant of relatively small capacity. The company officials believe that the process was technically sound but that the facilities did not prove to be suited to the operation.

The Defense Plant Corporation customs concentrator at Butte, Mont., began operations during January 1944, with the Domestic Manganese & Development Co. as agent for Metals Reserve Company. Manganese oxide and carbonate ores from Philipsburg were treated. However, it was discovered that flotation was more satisfactory, using carbonate ores alone, and the use of oxides was discontinued. During the year this mill produced (dry) 19,277 net tons of nodules averaging 51.02 percent Mn, 3.4 percent Fe, 12.02 percent  $\text{SiO}_2$ , and 0.48 percent P.

The largest shipment of manganese concentrates in the United States during 1944 came from the Old Dominion mine in Augusta County, Va., operated by the Dominion Manganese Corp., New York City. Shipments from this mine during 1944 totaled 12,943 short tons of psilomelane ore averaging (natural) 41.93 percent Mn, 3.83 percent Fe, 10.82 percent  $\text{SiO}_2$ , 0.159 percent P, and 4.17 percent moisture. The ore is mined by open-pit methods and concentrated by log washing, hand sorting, and jigging.

Domestic production, which depended largely upon Government purchases during the war, was curtailed during 1945 as a result of new specifications which excluded ore containing less than (dry) 42 percent Mn. Output, as measured by shipments from mines, totaled 182,337 short tons compared with 247,616 tons in 1944. The value of manganese ore shipped in 1945 totaled \$7,320,309 (\$40.15 per short ton) compared with \$9,014,875 (\$36.41 per ton) in 1944. However, a larger proportion of high-grade ore was shipped in 1945, and the average price per long-ton unit increased only slightly -- from 77 cents in 1944 to 79 cents in 1945. Eleven States contributed in 1945 compared with 13 during the previous year. The total number of shippers dropped from 133 in 1944 to 37 in 1945. At the end of 1945 there were no provisions for Government purchases of domestic manganese ore. Shipments of ferruginous manganese ore (10 to 35 percent manganese) amounted to 114,327 tons, and shipments of manganiferous iron ore (5 to 10 percent manganese) were 1,408,527 tons compared with 297,136 and 1,190,476 tons, respectively, in 1944.

Manganese ore stockpiled by the Office of Metals Reserve (successor to Metals Reserve Company, July 1, 1945) paced releases to industry during 1945. At the close of the year, ore stored by this agency in the United States totaled 1,076,113 long dry tons, compared with 991,341 tons at the end of 1944. Domestic ore comprised 25 percent (266,476 tons) compared with 26 percent (245,117) on December 31, 1944. Total storage outside the United States (Brazil and Chile) on December 31, 1945, was 181,770 tons; on the same date of 1944, foreign storage (Chile and Cuba) amounted to 252,647 tons.

All Government purchases of domestic manganese ore ceased at the close of 1945; purchases of manganese nodules from the Anaconda Copper Mining Co., the largest domestic supplier, terminated on September 30, 1945.

Stocks of manganese ore held by the Office of Metals Reserve declined steadily throughout 1946. Adjusting the data reported by that agency to include an average of 4 percent moisture, 1,234,802 short tons were on hand at the end of the first quarter of 1946. At the end of the year this figure had been reduced to 1,095,427 tons.

During 1946 the Government again became a potential buyer of manganese ore when, under Public Law 663, signed by the President on August 8, 1946, Congress provided an initial appropriation of \$100,000,000 for purchasing strategic and critical commodities. The Strategic and Critical Materials Division of the Procurement

Division (Bureau of Federal Supply, after January 1, 1947) of the Treasury Department, under the direction of the Secretaries of War and Navy, was authorized under Public Law 520 (signed July 23, 1946) to make purchases for the stockpiling program. The Army and Navy Munitions Board announced a plan to complete the program within 5 years at a total cost of \$2,100,000,000. (6) No statistical data have been published regarding tonnages secured or expenditures made under the stockpiling program.

### Prices

The elimination of price control on manganese ore, effective November 9, 1946, under Executive order, had little or no effect on the price of manganese ore in the United States, as the sale price had previously been considerably under the ceiling fixed by the Office of Price Administration. Prices quoted by E&MJ Metal and Mineral Markets, at the close of 1946, per long-ton unit, for ore containing 48 percent manganese, subject to premiums and penalties, ranged from 70 to 71 cents, including duty.

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## XXIII. BUSINESS STATISTICS



## CHAPTER XXIII BUSINESS STATISTICS

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## XXIII. BUSINESS STATISTICS

Table XXIII-1. INDUSTRIAL PRODUCTION-INDEXES FOR MINERALS, 1919-50.

Adjusted for seasonal variation. 1935-39 average = 100

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1919	73	65	62	66	69	71	75	73	79	81	59	72	71
1920	80	79	81	76	79	82	82	85	79	85	87	88	83
1921	76	72	67	67	69	66	63	64	62	66	64	64	66
1922	72	79	85	50	50	55	53	58	76	84	88	93	71
1923	92	93	97	103	101	100	103	102	93	98	98	91	98
1924	94	98	92	86	86	86	86	85	90	90	89	90	89
1925	94	91	89	94	96	96	97	99	86	85	87	86	92
1926	85	89	98	98	96	99	100	101	102	105	108	109	100
1927	106	108	113	99	100	99	95	100	97	96	95	94	100
1928	95	94	99	96	98	96	96	99	100	102	105	102	99
1929	108	110	103	108	107	106	109	108	110	107	103	106	107
1930	103	100	94	96	96	95	93	91	89	89	87	85	93
1931	82	80	83	83	82	83	82	76	75	78	79	77	80
1932	70	69	74	69	63	60	61	63	67	69	69	65	67
1933	66	69	71	65	76	80	83	87	81	77	77	76	76
1934	78	80	85	80	81	80	80	79	79	77	78	80	80
1935	84	85	87	80	83	91	82	83	85	90	91	93	86
1936	95	97	91	98	96	97	99	99	100	102	106	107	99
1937	105	109	119	110	111	115	113	115	116	113	110	107	112
1938	103	97	98	95	90	92	94	97	97	99	102	102	97
1939	103	101	104	91	97	104	107	92	114	119	120	114	106
1940	120	115	118	120	118	119	118	113	117	114	119	119	117
1941	120	119	126	96	121	127	126	128	132	134	133	134	125
1942	133	133	126	125	126	127	126	130	131	129	130	127	129
1943	125	131	132	131	129	117	135	135	138	136	133	137	132
1944	139	142	139	140	143	142	139	142	143	143	143	137	140
1945	140	141	142	140	138	144	143	140	134	124	138	133	137
1946	141	141	137	104	115	139	146	144	146	145	136	137	134
1947	146	146	148	143	151	148	140	150	153	155	155	156	149
1948	154	155	142	147	162	159	153	159	156	158	161	156	155
1949	149	149	136	148	145	133	123	129	119	112	141	132	135
1950	130	118	144	140	145	151	144	159	163	166	160	157	148
1951	164	158	158	164	165	165	156	165	167	174	170	163	164
1952	167	167	164	166	141	146							

Source: Federal Reserve System

Table XXIII - 2. INDUSTRIAL PRODUCTION-INDEXES FOR TOTAL,  
MANUFACTURES, AND MINERALS 1919-50.

Adjusted for seasonal variation 1935-39 average = 100

	Jan.	Feb	Mar.	Apr	May	June	July	Aug	Sept.	Oct.	Nov.	Dec	Average
1919	71	68	66	67	67	72	75	77	75	74	74	74	72
1920	82	82	81	76	78	78	76	77	74	72	66	62	75
1921	58	57	55	55	58	56	56	58	58	61	61	61	58
1922	63	65	69	67	70	74	74	72	76	80	84	86	73
1923	85	86	89	91	92	91	90	88	87	86	86	84	88
1924	86	88	86	83	80	76	75	78	81	82	84	86	82
1925	89	89	89	90	90	89	91	90	88	92	94	95	90
1926	93	93	95	94	94	95	95	96	98	98	97	97	96
1927	96	97	99	96	97	96	95	95	94	92	92	93	95
1928	94	95	96	95	97	98	99	101	101	103	105	107	99
1929	108	108	108	110	112	113	114	114	112	110	105	100	110
1930	100	100	98	98	96	93	89	86	85	83	81	79	91
1931	78	79	80	80	80	77	76	73	70	68	67	66	75
1932	64	63	62	58	56	54	53	54	58	60	59	58	58
1933	58	57	54	58	68	78	85	82	77	73	69	70	69
1934	72	75	79	79	80	79	73	73	70	71	72	77	75
1935	83	85	84	82	83	84	84	87	89	92	94	95	87
1936	94	92	93	98	100	103	104	106	108	110	113	116	103
1937	116	118	120	120	121	119	120	115	107	107	87	87	113
1938	85	84	84	82	81	81	86	90	93	96	100	101	89
1939	101	101	101	98	99	103	106	106	115	122	124	124	109
1940	122	117	114	114	118	123	123	126	129	132	136	140	125
1941	143	147	152	149	160	164	166	167	169	172	174	176	162
1942	181	183	186	189	191	193	197	204	208	215	220	223	199
1943	227	233	235	237	238	236	239	242	244	247	247	241	239
1944	243	244	241	239	236	235	230	232	230	232	232	232	235
1945	234	236	235	230	225	220	210	186	167	162	168	163	203
1946	160	152	168	165	159	170	172	178	180	182	183	182	170
1947	189	189	190	187	185	184	176	182	186	191	192	192	187
1948	193	194	191	188	192	192	186	191	192	195	195	192	192
1949	191	189	184	179	174	169	161	170	174	166	173	179	176
1950	183	180	187	190	195	199	196	209	211	216	215	218	200
1951	221	223	222	223	222	221	212	217	218	218	219	218	220
1952	221	222	221	216	211	203							

Source: Federal Reserve System

Table XXIII - 3. WHOLESALE PRICES, ALL COMMODITIES

1926 = 100.0

1890	56.2	1912	69.1	1934	74.9
1891	55.8	1913	69.8	1935	80.0
1892	52.2	1914	68.1	1936	80.8
1893	53.4	1915	69.5	1937	86.3
1894	47.9	1916	85.5	1938	78.6
1895	48.8	1917	117.5	1939	77.1
1896	46.5	1918	131.3	1940	78.6
1897	46.6	1919	138.6	1941	87.3
1898	48.5	1920	154.4	1942	98.8
1899	52.2	1921	97.6	1943	103.1
1900	56.1	1922	96.7	1944	104.0
1901	55.3	1923	100.6	1945	105.8
1902	58.9	1924	98.1	1946	121.1
1903	59.6	1925	103.5	1947	152.1
1904	59.7	1926	100.0	1948	165.1
1905	60.1	1927	95.4	1949	155.0
1906	61.8	1928	96.7	1950	161.5
1907	65.2	1929	95.3	1951	180.4
1908	62.9	1930	86.4	1952	
1909	67.6	1931	73.0	1953	
1910	70.4	1932	64.8	1954	
1911	64.9	1933	65.9	1955	



Table XXIII - 4. WHOLESALE PRICES, METALS & METAL PRODUCTS

1926 = 100.0

1890	105.3	1912	89.5	1934	86.9
1891	92.2	1913	90.8	1935	86.4
1892	84.0	1914	80.2	1936	87.0
1893	76.8	1915	86.3	1937	95.7
1894	65.7	1916	116.5	1938	95.7
1895	70.4	1917	150.6	1939	94.4
1896	71.2	1918	136.5	1940	95.8
1897	65.0	1919	130.9	1941	99.4
1898	65.3	1920	149.4	1942	103.8
1899	100.0	1921	117.5	1943	103.8
1900	98.0	1922	102.9	1944	103.8
1901	93.1	1923	109.3	1945	104.7
1902	91.0	1924	106.3	1946	115.5
1903	90.2	1925	103.2	1947	145.0
1904	79.9	1926	100.0	1948	163.6
1905	89.1	1927	88.3	1949	170.2
1906	102.4	1928	84.3	1950	173.6
1907	109.8	1929	100.5	1951	189.2
1908	86.3	1930	92.1	1952	
1909	84.5	1931	84.5	1953	
1910	85.2	1932	80.2	1954	
1911	80.8	1933	79.8	1955	

U. S. Department of Labor, Bur. of Statistics

Table XXIII - 5. ALL COMMODITIES

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Aver.
1940	79.4	78.7	78.4	78.6	78.4	77.5	77.7	77.4	78.0	78.7	79.6	80.0	78.6
1941	80.8	80.6	81.5	83.2	84.9	87.1	88.8	90.3	91.8	92.4	92.5	93.6	87.3
1942	96.0	96.7	97.6	98.7	98.8	98.6	98.7	99.2	99.6	100.0	100.3	101.0	98.8
1943	101.9	102.5	103.4	103.7	104.1	103.8	103.2	103.1	103.1	103.0	102.9	103.2	103.1
1944	103.3	103.6	103.6	103.9	104.0	104.3	104.1	103.9	104.0	104.1	104.4	104.7	104.0
1945	104.9	105.2	105.2	105.7	106.0	106.1	105.9	105.7	105.2	105.9	106.8	107.1	105.8
1946	107.1	107.7	108.9	110.2	111.0	112.9	124.7	129.1	124.0	134.1	139.7	140.9	121.1
1947	142.0	145.2	150.0	148.0	147.3	147.7	150.6	153.7	157.4	158.5	159.6	163.2	152.1
1948	165.9	161.0	161.0	163.0	164.2	166.4	168.8	169.8	165.9	165.4	164.0	162.4	165.1
1949	160.7	158.4	158.6	157.1	155.8	154.5	153.6	152.9	153.5	152.2	151.6	151.2	155.0
1950	151.5	152.7	152.7	152.9	155.9	157.3	162.9	166.3	169.5	169.1	171.7	175.3	161.5
1951	180.2	183.7	184.0	183.6	182.9	181.7	179.4	178.0	177.6	178.1	178.3	177.8	180.4

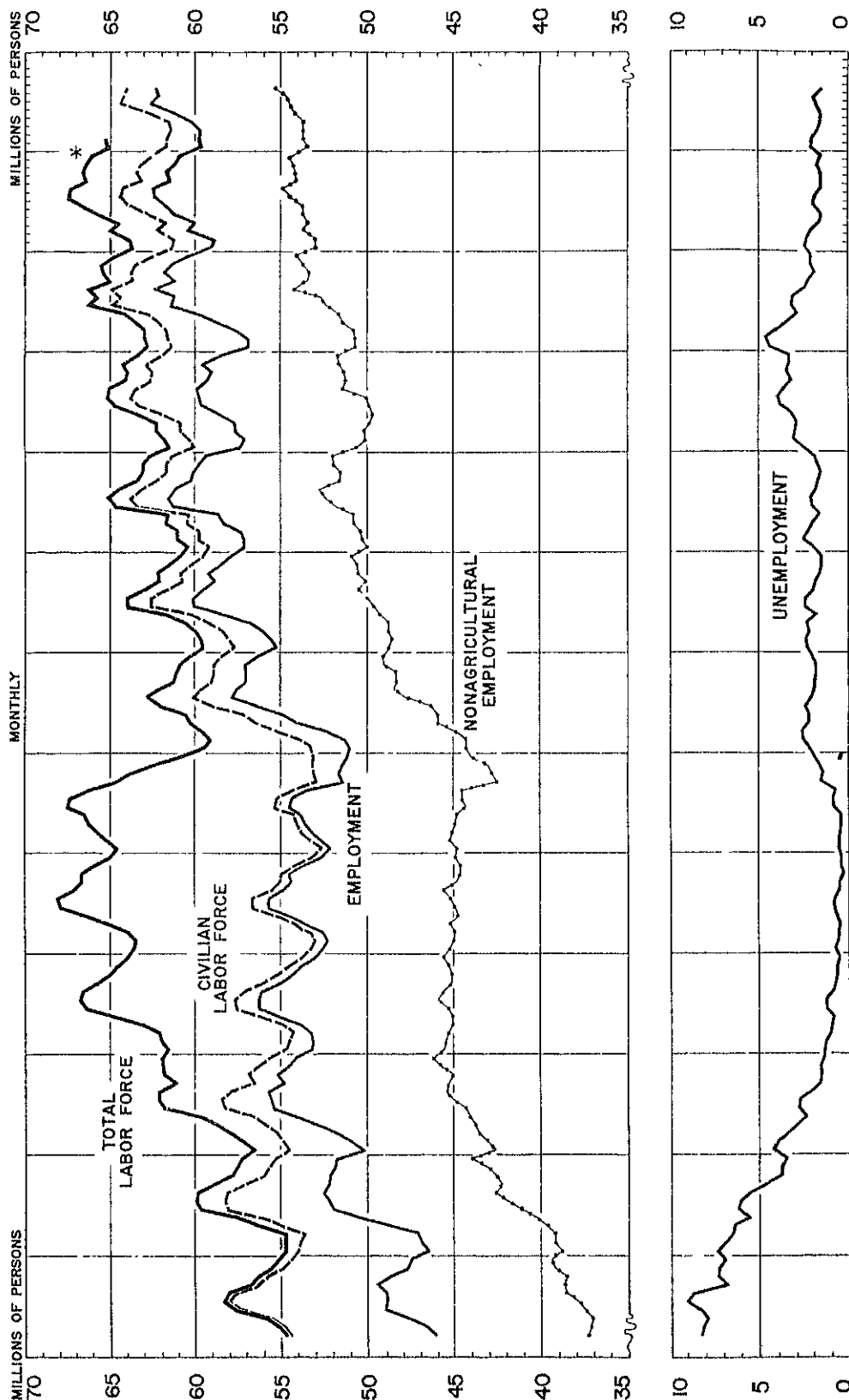
Table XXIII - 6. METALS AND METAL PRODUCTS

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year Aver.
1940	95.8	95.3	95.5	94.5	94.5	94.7	95.1	94.9	95.4	97.3	97.6	97.6	95.8
1941	97.7	97.6	97.7	97.9	98.1	98.3	98.5	98.6	98.6	103.1	103.3	103.3	99.4
1942	103.5	103.6	103.8	103.8	103.9	103.9	103.8	103.8	103.8	103.8	103.9	103.8	103.8
1943	103.8	103.8	103.8	103.8	103.8	103.8	103.7	103.7	103.7	103.7	103.8	103.8	103.8
1944	103.7	103.7	103.7	103.7	103.7	103.7	103.7	103.8	103.8	103.7	103.7	103.8	103.8
1945	104.0	104.2	104.2	104.2	104.3	104.7	104.7	104.7	104.9	105.0	105.2	105.6	104.7
1946	105.7	106.6	108.4	108.8	109.4	112.2	113.3	114.0	114.2	125.8	130.2	132.7	115.5
1947	139.0	139.6	141.1	141.3	141.9	142.0	143.1	148.5	150.1	150.5	151.5	151.5	145.0
1948	154.3	155.3	155.9	157.2	157.1	158.6	162.2	171.0	172.0	172.4	173.3	173.8	163.6
1949	175.4	176.3	175.4	172.4	168.9	167.1	167.9	168.2	168.2	167.3	167.3	167.8	170.2
1950	168.4	168.6	168.5	168.7	169.7	171.7	172.4	173.8	176.7	178.6	180.4	184.9	173.6
1951	187.5	188.1	188.8	189.0	188.8	188.2	187.9	188.1	189.1	191.2	191.5	191.5	189.2

U. S. Dept. of Labor, Bureau of Labor Statistics

# LABOR FORCE, EMPLOYMENT, AND UNEMPLOYMENT

BUREAU OF THE CENSUS ESTIMATES, WITHOUT SEASONAL ADJUSTMENT

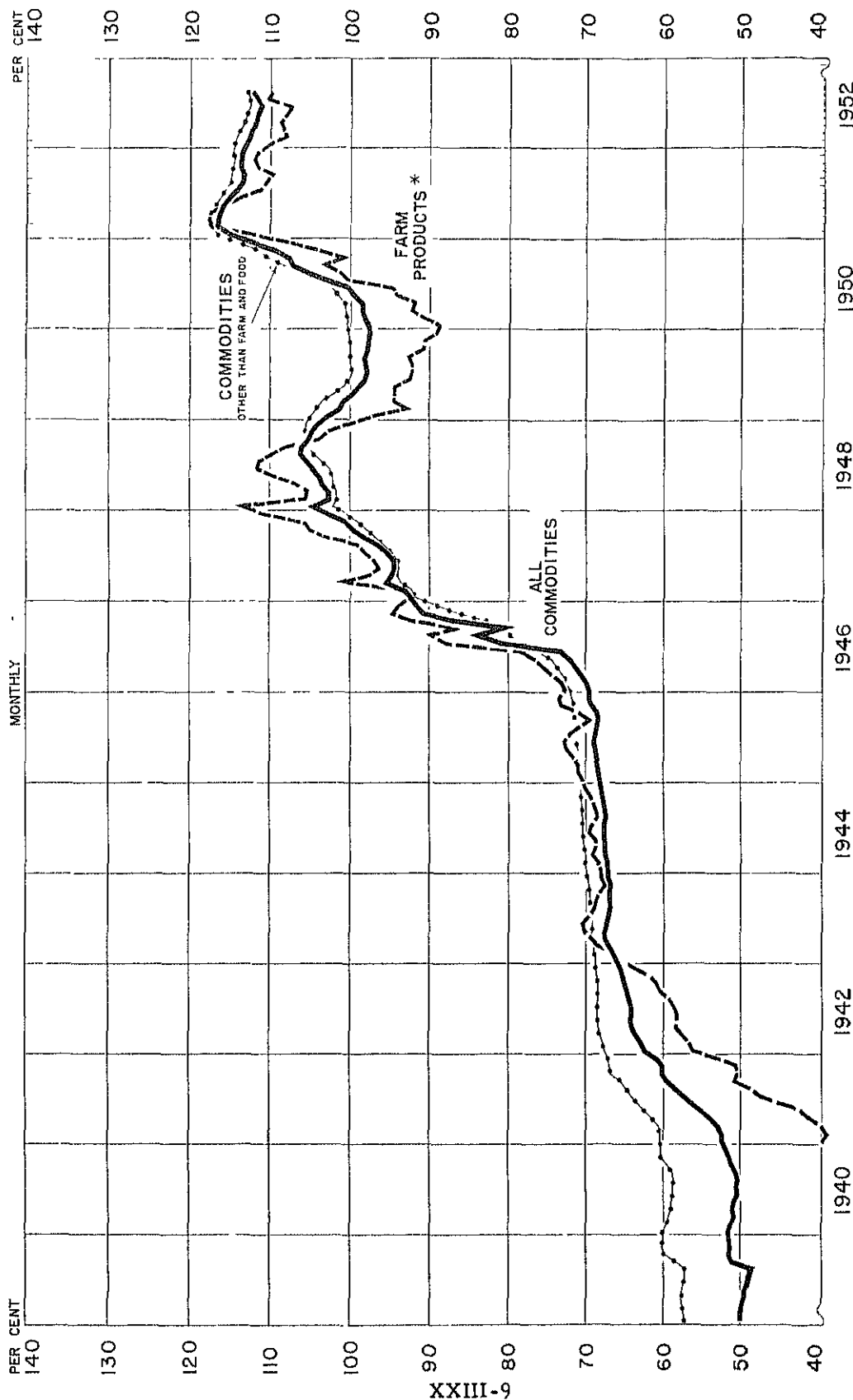


LATEST FIGURES PLOTTED AUGUST \* CURRENT DATA NOT AVAILABLE UNTIL 6 MONTHS LATER

FIGURE XXIII-1. Labor Force, Employment, and Unemployment.

# WHOLESALE PRICES

BUREAU OF LABOR STATISTICS INDEXES, 1947 = 49 = 100



\* FARM PRODUCTS NOT SHOWN PRIOR TO JANUARY 1941

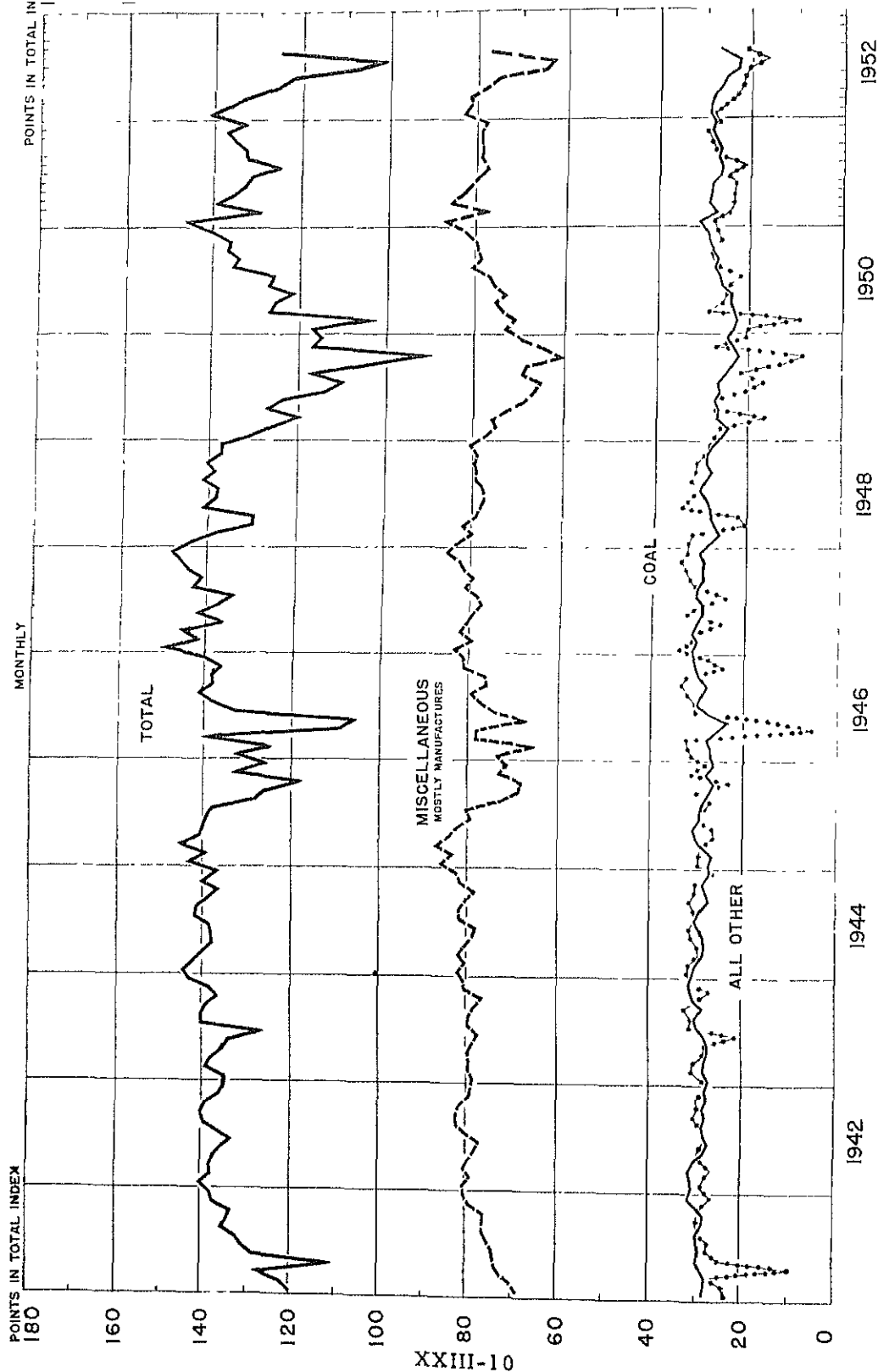
FIGURE XXIII-2. Wholesale Prices

LATEST FIGURES PLOTTED: AUGUST (EST.)

SCALING SYSTEM

# FREIGHT CARLOADINGS

F R INDEX ADJUSTED FOR SEASONAL VARIATION 1935 - 39 AVERAGE FOR TOTAL • 100

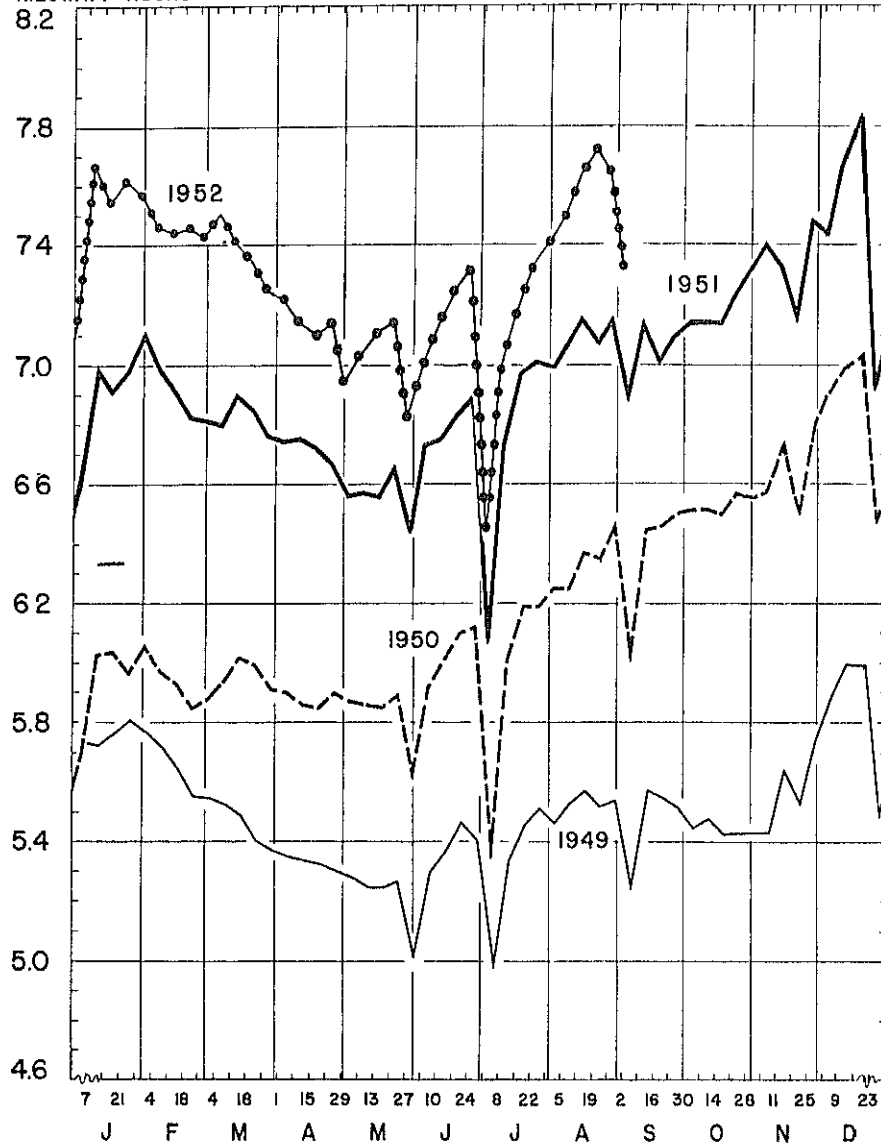


LATEST FIGURES PLOTTED AUGUST

FIGURE XXIII-3. Freight Carloadings

# ELECTRIC POWER PRODUCTION

BILLIONS OF  
KILOWATT HOURS



LATEST FIGURES PLOTTED SEPTEMBER 6

BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

FIGURE XXIII-4. Electric Power Production

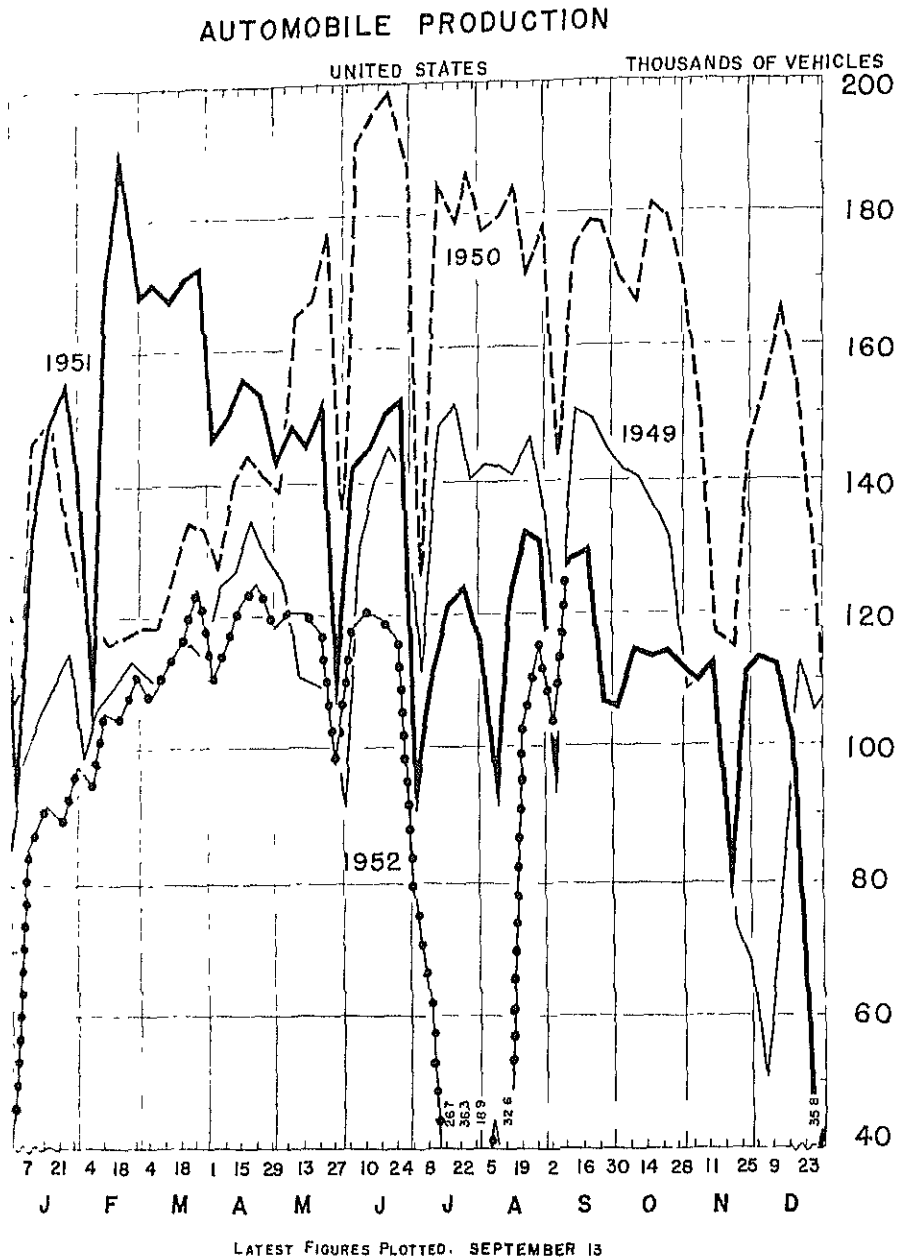


FIGURE XXIII-5. Automobile Production

Line graph showing monthly gold exports in millions of tons from January 1949 to December 1952. The Y-axis ranges from 0.8 to 2.4 million tons. The X-axis shows months from J to D. Five lines represent the years 1949, 1950, 1951, and 1952. 1949 shows a sharp peak in August. 1950 shows a sharp drop in March. 1951 and 1952 show higher overall export levels with significant fluctuations.

Y-axis: MILLIONS OF TONS (0.8 to 2.4). X-axis: Months (J to D). Lines represent years 1949, 1950, 1951, and 1952.

Latest figures plotted: September 13.

Source: BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM.

XXIII-13